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Section of Plant Quarantine and Inspection

Pittsburgh, Pa., Dec. 27, 1934

The section met at 10 a.m. with the Chairman, Mr. A. S. Hoyt, presiding.

The following committees were appointed:

Resolutions, E. L. Chambers, A. B. Buchholz.

Nominations, F. N. Wallace, E. R. Sasscer, C. J. Drake.

Mr. R. H. Bell presided during the address of the chairman, which follows:

A REVIEW OF THE PLANT QUARANTINE WORK IN 1934

By AVERY S. HOYT, *Washington, D. C.*

Custom gives this paper the title of "Address". It does not warrant such a title and would more properly be called "A Review of the Plant Quarantine Work in 1934".

The reorganization that took place within the United States Department of Agriculture during the past year is known to all. It brought together the Bureau of Entomology, the Bureau of Plant Quarantine, the plant-disease control and eradication activities of the Bureau of Plant Industry, and the Insecticide and Fungicide Division of the Bureau of Chemistry and Soils into one bureau known as the Bureau of Entomology and Plant Quarantine. The annual reports of the bureaus concerned discuss the work of these activities prior to the date of consolidation. Consequently, this paper will emphasize only a few points covered by these reports and will devote itself more specifically to happenings not included in the annual reports or which have taken place since July 1st.

DOMESTIC PLANT QUARANTINES

DATE SCALE.—During recent years, entomologists and agricultural workers have given more and more attention to eradication of insect pests and plant diseases where practicable rather than merely to control. An instance of this tendency is afforded by the Date Scale Eradication program of the Department in cooperation with the States of Arizona

and California. This project has been under way for a number of years and appears to have reached a point where a successful outcome may be anticipated. Inspection and clean-up work was continued in the date-growing areas of these States. No scale was found in the Salt River Valley of Arizona and none was found in the Yuma district of that State. No scale has been found in the Yuma district for the past 3 years and but one infested palm has been found in Arizona in the past 6 years. No scale has been found in the Coachella Valley in California since January 1931. In the Imperial Valley 11 infested date palms were found on one property. This infestation was found on a property previously found infested and which was thought to have been cleaned up.

Tree-to-tree inspections have been continued. In addition, worthless and abandoned palms have been destroyed wherever possible, hundreds of palms have been heavily pruned to facilitate inspection, and others have been stripped of fiber to permit inspection of leaf bases. A section-by-section survey of areas involved is in progress to locate unlisted abandoned palms. Many plantings have been given their final inspections and are considered free from Parlatoria scale. It is expected that additional plantings will be similarly released from inspection during the coming year as this project draws towards its completion.

Gypsy Moth.—Gypsy moth control activities for the year have been: (1) Searching for and suppressing the scattered infestations in the barrier zone and between the zone and the Connecticut River; (2) application of suppressive measures in the outlying infestations of Pennsylvania and New Jersey; and (3) quarantine enforcement.

An important development was the finding of an infestation in the Bronx, New York, in June 1934. Work on this infestation was undertaken promptly by the New York State Department of Conservation, which department also has responsibility for the work against the infestation on Long Island. The size of the area involved is now known to be 9 square miles though it may be found to be somewhat larger as scouting continues.

The work during the greater part of the fiscal year 1934 was carried on under an allotment of funds from the P W A. As a result of infestations found in the barrier zone and east of it as far as the Connecticut River and in Pennsylvania, the largest spraying program ever undertaken against this pest was carried out during June; 245 tons of lead arsenate were applied, the coverage including 11,537 acres of woodland, 8,272 isolated trees, and 2,763 residential properties.

Another result was the moving of the western boundary of the regulated area eastward to exclude from the quarantine the scouted area in northern Vermont where no infestations were found.

In Pennsylvania an increase of the area followed the finding of additional infestations until now this territory includes 880 square miles. Work there is being done in cooperation with the State Department of Agriculture and the State Department of Forests and Waters. A State quarantine regulates the movement of products out of the infested area.

In addition to the change in the quarantined area mentioned above, a number of townships in Maine, New Hampshire, Vermont, and Con-

necticut previously classed as lightly infested were reclassified as heavily infested. Nurseries and quarries in uninfested portions of the lightly infested area have been given an opportunity to operate under a permit system. Issuance of permits is limited to establishments where inspection of premises and surroundings results negatively, and such permits are subject to cancellation if subsequent shipments do not originate in free territory or are not properly certified. Limited operation of vehicle-inspection stations during the past year has resulted in the interception of uncertified material destined for points outside the regulated area and some of this material has been found infested with egg clusters of the gypsy moth.

JAPANESE BEETLE.—This year, for the first time since 1928, no change in the quarantine on account of increase in area infested by the Japanese beetle has been found necessary. To make the results of the season's trapping program public the Bureau has recently distributed a brief report of the season's work. It discloses, in addition to other smaller and less significant finds, that 1,351 beetles were taken in traps in St. Louis, 17 in Indianapolis, and 60 in Charlottesville. The St. Louis infestation must be considered as established, since it is known that the insect has been in that city since 1932, although information to this effect did not reach the Bureau until early in 1934. Soil treatment has been completed in all three cities, and in St. Louis the State Department of Agriculture has established a quarantine to delay spread from that point. Since the St. Louis Japanese beetle situation is to be discussed on this program, it needs no further mention here, except as to the means by which this work was financed. St. Louis is in the area involved in the 1934 drought and hence an allotment of $65,000 from the appropriation "Loans and Relief in Stricken Agricultural Areas" was made available by Executive order in time to permit the work to be done at that point.

It is situations such as these which emphasize the need for some suppressive measure, not too expensive, to permit more aggressive action against the Japanese beetle in these outlying infestations. Attention is being given to this problem by research workers, but opportunity is taken to emphasize its importance. The present method, consisting of soil treatment accompanied by the use of traps, is the most effective measure available. While this delays the building up of the insect population in new points and correspondingly delays the time when these points will in turn become centers of spread, yet such measures do not go as far towards extermination as is to be desired. The cost of lead arsenate applied at the rate of 1,000 pounds per acre is a serious drawback, particularly since delayed upbuilding of insect population is the best that can be hoped for. A further disadvantage is that no assurance can be given as to the length of time this delayed upbuilding of population can be expected to last. The Japanese beetle laboratory at Moorestown is working on this problem.

PINK BOLLWORM.—In September, and again in October, the quarantine on account of the pink bollworm of cotton was amended because the insect was found in areas not known to be infested. The additions in territory include seven counties in northern Florida and two counties and

part of a third in Texas. In three Florida counties the change was made because the lack of ginning facilities necessitated the farmers' taking their cotton to gins in the regulated area. In none of the counties recently added to the regulated area has evidence of heavy infestation been found. In fact, it appears that infestation is very light.

The measures employed to control and prevent the spread of the pink bollworm are (1) disposal of trash at the gins, (2) sterilization of seed, (3) supervision of oil mills, (4) sterilization of lint, (5) inspection at road stations, and (6) cooperation with Mexico. To these should be added the cleanup in the Big Bend area of Texas. This area is exposed to reinfestation from cotton grown in Mexico. A field cleanup is made there, having for its object the reduction of the worm population in that area. It includes, besides the field cleanup, a house-to-house canvass to locate small lots of seed cotton which may have been held over.

In southern Florida, on the mainland and on the keys, the effort to eradicate wild cotton, begun in 1932 with work in the vicinity of highways and points likely to be visited by tourists, has been extended farther each year until, at the end of last season, only one region known to contain wild cotton had not been worked at least once. It is found that plants destroyed are replaced by seedlings and sprouts from roots left in the soil. Where it has been possible to go over the ground enough times in a single season, noticeable decrease in the number of plants has been observed. Infestation continues to be found in some locations in this cotton where blooms have been able to mature.

The most satisfactory method of scouting is that in which the gin-trash machines are used. In order to reach gins at isolated points or those at which the supply of trash at any given time is small, a smaller hand machine has been developed. This machine weighs only about 75 pounds and can be readily transported, handle a small run of trash, and then again be moved. The efficiency of the small machines has been demonstrated by the finding of several light infestations during the present year.

MEXICAN FRUIT FLY.—There are 8,201,211 citrus trees now set out in grove formation in the Lower Rio Grande Valley in Texas and of this number about 5,000,000 have reached bearing age. Production of fruit for the current year is estimated at 7,300 carloads, of which about 2,000 cars had been shipped by the middle of December. Exposed to more or less constant reinfestation from Mexico, the problem here is to provide for movement of the fruit without danger of spreading the pest and to suppress the recurring infestations as rapidly and effectively as possible. The work is based on grove inspection and sanitation, certification of fruit, maintenance of a non-host season, inspection at road stations, and cooperation with Mexico.

The use of the new glass traps has resulted in the capture of fruit flies in greater numbers than was possible before. No index of fly population of comparable accuracy has been available before and, therefore, there are no previous data to compare with the first year's work with these traps. Traps were operated during the year in 1,440 groves, in 176 of which adult flies were taken. Despite intensive inspection of fruit

in these and other properties, no larvae were found during the shipping season. At the end of each season, a tree-to-tree inspection is made to get the few remaining fruits missed by the pickers, and this year larvae were found in such fruit on four properties. This compares with negative results during the previous year and with the finding of larvae on 61 properties in 1932.

Supplementing the host-free period, an effort has been made to reduce the number of non-citrus trees within the regulated area. During the past fiscal year, 330 were removed, making a total of 40,623 such trees that have been destroyed during the past six years.

Cooperation has been received from the Mexican border communities where fruit growing is not of commercial importance. Their supplies are brought from interior points and many of them are infested. The Mexican officials cooperate in efforts to discourage the shipment of infested fruits. They permit representatives of the Bureau to inspect these shipments and to segregate and destroy any found infested. Despite these efforts, a total of 18,636 specimens of *Anastrepha* were taken on the Mexican side of the Rio Grande during the fiscal year. Of the imported fruits, mangoes were found to be most heavily infested, 10,669 larvae having been taken from this fruit during June.

The nicotine-molasses spray was applied to all groves in which adult flies had been taken in traps. Fruit flies taken during the year include, in addition to *A. ludens*, other species of *Anastrepha*, among them *A. pallens*, which has been found thus far to attack the fruit of a native plant only and thus to have no economic significance, *A. serpentina*, *A. fraterculus*, *A. striata*, and two other species not yet identified and of doubtful economic importance; also the papaya fruit fly, *Toxotrypana curvicauda*, which attacks the papaya only.

During the year, consideration was given to a proposal originating with the Department of Agriculture of Mexico that an international commission be created to study the problems common to Mexico and the United States in connection with the Mexican fruit fly. After careful consideration, a favorable decision was reached with respect to this proposal and the commission, consisting of three representatives from the agricultural department of each of the two countries, has been created.

White Pine Blister Rust.—White pine blister rust control seeks local protection of the various pine stands of the United States by destroying currant and gooseberry plants, the alternate hosts of the rust.

Emergency funds have contributed to this program. The CCC has covered over 1,500,000 acres in and near pine stands. In August 1933 the PWA made an allotment of $2,050,000 for blister rust control, and a substantial sum to the Forest Service for work on the national forests. During the present fiscal year, the administrative as well as much of the field work is financed under that PWA allotment.

In a number of States the Federal Emergency Relief Administration has aided blister rust control. These emergency organizations have made possible *Ribes* eradication in the Southern Appalachians and in the Lake States, also a somewhat enlarged scale of work in the Northeast

and Northwest. Of the 20,000,000 acres from which the *Ribes* need to be eradicated in order to protect the white pine stands of the United States, 12,400,000 have now been covered at least once.

Reforestation has resulted in the establishment of large-scale nurseries of forest trees and in enlargement of nurseries already established. For protection against blister rust, the Department inspects the nurseries which ship interstate. It is said that when present nurseries reach capacity development, within the next two or three years, they will have 18,500,000 5-leaf pines, besides other forest trees. It is believed that as many more 5-leaf pines are growing in protected nurseries operated by State forestry departments. Since these State nurseries do not ship interstate, they are not inspected by the Bureau.

Blister rust is gradually increasing its range, having been found this year in Nelson County, Virginia, in its spread along the Appalachian Mountains. Spread also occurred southward and eastward in Oregon, but the disease has not yet been discovered in California. In Geauga County, Ohio, it was recently discovered that an infection center is developing.

BARBERRY ERADICATION.—Barberry eradication is carried out to prevent black stem rust outbreaks in the grain-growing States. Federal emergency funds made it possible to continue progress. An allotment from the PWA and a number of local Civil Works projects in the Mississippi Valley provided for continuation of the work in several extensive areas. It has not as yet been possible to cover thoroughly all localities in which escaped barberries are known to be growing, and a considerable amount of work still remains to be done. The total number of barberry plants destroyed during the calendar year 1934 (up to November 30) was 481,707. As usual, the premises of those nurserymen who desired to ship resistant species of barberries and *Mahonia* into and between the 13 protected Middle Western States have been visited to make certain that they are not growing susceptible species of these plants. At present 23 nurseries have Federal permits of this kind.

DUTCH ELM DISEASE.—There are two papers on this program dealing with the Dutch elm Disease and hence it needs only brief mention here. While perhaps it cannot be said that there is absolute proof as to how it entered this country, port inspectors observed bark beetles imported on elm burl logs, and this, when brought to the notice of the Bureau of Plant Industry, led to investigations by that Bureau indicating in a very striking way the probability that such logs are chiefly responsible. A little over a year ago a quarantine was promulgated and its restrictions sought to safeguard the entry of these logs. However, one of these safeguards was the removal of the bark, and subsequent experience has shown that it is practically impossible to remove the bark thoroughly enough to accomplish the purpose. Therefore, by recent action, effective January 1, 1935, the restrictive quarantine is being superseded by an embargo.

It is believed possible that elm sticks with bark used on packing cases may serve to carry the disease. The Bureau does not have enough men to examine all the packing cases entering this country. To reduce this

risk as far as possible, importers of those products most likely to be packed in cases using elm wood have been asked to specify in future that no elm wood be used.

PUBLIC CONFERENCES.—Early in December, three public conferences were held in Washington to analyze and consider the status of white pine blister rust, the gypsy moth, and Dutch elm disease. The announcement of these conferences stated their purpose, namely, to "consider the present value of the control programs, their need and effectiveness, whether they should be continued, and the desirability of making modifications or changes." No statement with reference to these conferences has yet been made.

CONTROL CAMPAIGNS.—While not exactly quarantine or inspection, reference should not be omitted to campaigns using emergency funds for employment purposes to bring about widespread pest control. One such was against the brown-tail moth under the CWA. It began in December 1933, ended in February 1934, gave employment to more than 4,500 persons, and resulted in destruction in Maine, New Hampshire, Massachusetts, and Vermont of 19,954,249 webs. Subsequent action by these States resulted in destruction of 3,900,000 additional webs.

Another such project was concerned with pest mosquitoes in 33 States and the District of Columbia. It resulted in 1,930 miles of ditches dug, 400 miles of stream banks cleared, deepened, and straightened, 53,020 feet of dikes constructed, 7,556 feet of metal and concrete culverts installed, and half as much more repaired or reset, 400,000 cubic yards of dirt and rock moved, 7,600 acres of brush cleared, and 4,000 feet of tile drain installed, giving employment to 21,617 men.

There was also the sweet potato weevil project in five States, showing 100 per cent completion in one, 85 per cent in each of two, 50 per cent in the fourth, and an undetermined amount finished in the fifth.

While not employment measures, reference should also be made to the grasshopper and chinch bug campaigns of last summer. The grasshopper project, financed by an appropriation of $2,354,893, succeeded in distributing approximately 78,000 tons of bait throughout the infested territory.

This was followed by the chinch bug project, supported by an appropriation of $1,000,000, with which there was purchased and distributed in the ten infested States 6,000,000 gallons of creosote to be used by the farmers in erecting barriers.

While of great importance in themselves, it is believed attention may properly be called to the alert response of State and Federal workers to these several problems, to which time does not permit our giving adequate consideration. A significant fact about these projects, different as they were in every other respect, is that all were based on cooperation between State and Federal workers.

EFFECT OF DROUGHT CONDITIONS ON STATE QUARANTINES.—Later on during this program, we will hear a paper on "Court Proceedings Affecting Pest Control Legislation," and while perhaps tests of the validity of various State quarantines have not been carried as far as the courts, yet there occurred during the past summer and fall a thorough scrutiny of

State quarantines. Owing to the drought in many States, there was and is an unusual demand for feed. This led to many queries as to moving alfalfa and corn fodder interstate. At times a feeling was manifested that the need for feed justified acceptance of pest risk, but the quarantines, so far as known, withstood the rather careful legal study on this account to which they were subjected. Associated with Federal drought relief activities, there has been the purchase of feed to be moved to the cattle. This has brought the various agencies up against State quarantines. It is worthy of record that Federal agencies thus engaged have respected State quarantines under such circumstances and these agencies are now engaged in so regulating the movement of surplus feed stuffs that violations of State quarantines will not occur. Private interests, likewise, so far as their activities are known to the Bureau, though seeking to sell their feed at a profit, are accepting the regulations of the various States. In one State (Nebraska) temporary modification of the alfalfa weevil quarantine became effective December 15.

Foreign Plant Quarantines

The Foreign Plant Quarantine work carried on at the various ports of entry resulted in some interesting interceptions of insects and plant diseases. Among these may be mentioned the following:

Insects Intercepted.—The Mexican fruit fly (*Anastrepha ludens*) was taken on 46 occasions in lime, mango, orange, sour orange, and sweet lime from Mexico. In one lot of 16 mangoes arriving in baggage at Del Rio, Tex., 80 living larvae of the Mexican fruit fly were found. The Central American fruit fly (*Anastrepha striata*) arrived three times in guava from Mexico. The melon fly (*Bactrocera cucurbitae*) was taken once in cucumber from Hawaii. The Mediterranean fruit fly (*Ceratitis capitata*) was intercepted on 21 occasions in apple, loquat, orange, sorbe apple, coffee, mango, fig, sour orange, tangerine, grape, and peach from the Azores, Hawaii, Italy, and Spain. In one lot of approximately 500 sorbe apples (*Sorbus domestica*) arriving in baggage from the Azores at Providence, R. I., 200 larvae and pupae of the Mediterranean fruit fly were found. The olive fruit fly (*Dacus oleae*) was found eight times in olives from Greece and Italy.

Larvae of the vine moth (*Polychrosis botrana*) were intercepted in grapes from Italy. The Asiatic rice borer (*Chilo simplex*) arrived with rice straw from China and Japan. Globe artichokes from Italy were infested with the weevil *Apion carduorum*. The bean pod borer (*Maruca testulalis*) was taken in beans from Cuba and China. The turnip gall weevil (*Ceutorhynchus pleurostigma*) infested turnips from England and the Netherlands, and cauliflower from Belgium. *Scolytus multistriatus* and *Scolytus scolytus* were intercepted in elm logs from France. *Epicaerus* sp., a weevil, was found in potatoes from Mexico. Cipollini from Morocco were infested with the chrysomelid *Exosoma lusitanica*. Another chrysomelid, *Psylliodes chrysocephala*, was intercepted in turnips from the Canal Zone, Denmark, England, and Norway, and in brussels sprouts from Denmark.

PLANT DISEASES INTERCEPTED.—The Dutch elm disease (*Ceratostomella* (*Graphium*) *ulmi*) with insect carriers was intercepted in burl elm logs from France at several ports, thus establishing the mode of entry of this disease. Citrus canker (*Bacterium citri*) was intercepted on *Citrus* spp. from China, Japan, and South India; citrus black spot (*Phoma citricarpa*) on fresh fruit from China and Japan; a rust (*Cerotelium desmium*) on cotton from West Indies; *Elsinoe piri* on apple from Switzerland; rusts (*Hemileia* sp., *Uredo epidendri*, *U. nigropunctata*, and *Uredo* sp.) on orchids from Dutch Guiana, Costa Rica, and Colombia. A number of diseases of ornamental plants caused by undescribed species of fungi were intercepted. Interceptions of nemas added Morocco and Russia to the list of countries from which the bulb nema (*Anguillulina* (*Tylenchus*) *dipsaci*) has been reported and included *Paraphelenchus amblyurus*, n. sp., in yams from Japan.

SOME INSECTS AND PLANT DISEASES NEW TO OR NOT GENERALLY DISTRIBUTED WITHIN THE COUNTRY

The Plant Quarantine Act refers to insects and plant diseases new to or not generally distributed within the country. Brief mention of a few of these may not be out of place in this report.

WEST INDIAN FRUIT FLY.—During the year the Department has cooperated with the Florida State Plant Board in its effort to eradicate the West Indian fruit fly from Key West. The PWA allotted $36,000 for this work in March. Additional traps have been bought, there being 500 now in operation. Two of the Department's gypsy moth power sprayers are being used. The FERA, now in charge of the Island, supplies some labor and cooperates in the removal and destruction of host fruits and host trees.

Since September 1933, no immature stages of any fruit flies have been found, notwithstanding the increased inspection work and the holding of large quantities of fruit in the laboratory on pupation trays. During this period, however, some 30 adult fruit flies have been trapped. These represent the two main forms of the West Indian fruit fly, *A. acidusa* and *A. suspensa*, and two undetermined species. Other control measures employed consist of the application of bait spray. This is done every month, and up to November 24 the thirty-first application had been made.

CITRUS BLACKFLY.—An infestation of the citrus blackfly (*Aleurocanthus woglumi*) was found on the island of Key West on August 10. The infestation is restricted to a portion of the island. Announcement of this finding has been made by the Florida State Plant Board. The keys between Key West and the ferry slip at No Name Key have been inspected twice and a rapid scout inspection has been made of the upper keys. To date no infestation has been found off the Island of Key West.

As a part of the eradication campaign, the State placed a quarantine on the island to regulate the movement of plants that might carry infestation. A spray program is under way, the second thorough application of oil spray having been completed before the first of November. Spraying is being continued.

BRACHYRHINUS LIGUSTICI.—This insect was found in a limited area near Oswego, N. Y., in October 1933. A survey was made during the last summer. The Bureau is cooperating with the State experiment station. The insect is a general feeder, but damage has been found only on alfalfa.

BEECH SCALE.—The beech scale, under observation in Maine and Massachusetts, has been the object of a survey conducted by the Bureau. An isolated infestation was found a short time ago at New Haven, Conn., and more recently one at Scarsdale, N. Y. Its presence has also been reported in New Jersey, but this latter report has not yet been confirmed.

THE PEA MOTH (*Laspeyresia nigricana*).—The pea moth, heretofore known in this country as a pest only in Wisconsin and Michigan, has been reported as damaging peas in Skagit and Whatcom Counties, Wash., for the past two or three years. Canadian authorities also report its presence in British Columbia.

NEW FUNGUS ATTACKING AZALEAS.—A new fungous disease known as blossom blight was discovered in the magnolia gardens near Charleston, S. C., in 1930. The pathologists report this as a heretofore-undiscovered fungus close to the genus *Botrytis*. Preliminary observations indicate that this fungus is carried by several species of bees and it is known to attack only the flowers of azalea.

THE TOMATO PINWORM (*Gnorimoschema lycopersicella*).—The tomato pinworm was first found in California in 1922, injuring tomatoes. It has since been reported from Bradenton, Fla., Las Cruces and Hatch, N. Mex., and from greenhouses in the Kennett Square area of Pennsylvania, Norfolk, Va., Gulfport and Long Beach, Miss., and St. Joseph, Mo. Infestations of tomatoes in the field adjoining the infested greenhouses have also been reported.

POSSIBLE FUTURE POLICIES IN PLANT QUARANTINE WORK

By LEE A. STRONG, *Washington, D. C.*

Since crystal gazing is always dangerous and generally unreliable, it is pleasing to note that the Secretary of this Section has qualified the title of the talk I am supposed to make by the word "possible" before the words "future policies in plant quarantine work." It is my purpose to discuss briefly two quarantines placed by the plant quarantine authorities of the Department, one of which seems to be in every way defensible while the other is one which is not easily defended.

First, Quarantine 56, the fruit and vegetable quarantine, provides that the fact has been determined that there exist in certain foreign countries and localities certain injurious insects that are not widely distributed within and throughout the United States and that on account of the danger to the United States of pest introduction, the unlimited importation of fruits and vegetables from the countries and localities named and from any other foreign countries or localities, is prohibited except under the regulations prescribed in the quarantine. The regulations then provide for the admission of fruits and vegetables in any

quantity whatsoever when it is shown that they do not constitute a danger to this country through the introduction of pests. If fruits or vegetables are known to be infested or if they present a definite risk of pest introduction to this country, they are not admitted in any quantity for any purpose whatsoever. This is a quarantine which is thoroughly sound and which can be defended from every standpoint.

The other quarantine is the nursery stock, plant and seed quarantine No. 37 which also provides that there exists in certain foreign countries and localities certain injurious insects and fungous diseases new to and not heretofore widely distributed within and throughout the United States and that plants and certain plant products from those and other countries and localities are prohibited entry into the United States except as provided in the rules and regulations laid down in the quarantine. The regulations then provide for the importation in unlimited amounts of certain types of plants whereas others are admitted in only limited quantities for necessary scientific, experimental, and propagation needs. Rose stocks, for example, which are not grown with the same care that finished roses are produced in nurseries, are admitted into this country in unlimited quantities. Anyone tomorrow can get a permit for 100,000,000 rose stocks merely by writing a postcard to the Bureau. Finished rose stocks, however, which have been grown under nursery care, of varieties which may be available in commercial quantities in this country, are not admitted at all. Finished varieties of roses not available in this country in commercial quantities are permitted importation for propagation purposes in limited amounts. This places the quarantine too much on the basis of availability and makes the quarantine in certain parts in fact a trade protection quarantine rather than one based entirely on the pest risk involved although the principle upon which the quarantine was established was thoroughly honest and was tenable if it could have been carried to its ultimate conclusion. This principle was that in reducing the number of importations the risk of pest introduction was correspondingly reduced. To carry it to the ultimate conclusion, however, would mean the absolute discontinuance of movement of all commerce from other nations to this one which involved any risk of pest introduction to this country. Obviously that could not be done so there is one course of procedure possible now and that is to get entirely out of any part of what may be construed as the tariff field.

Plants that can safely be admitted so far as pest risk is concerned should be admitted upon inspection in any quantity we are capable of inspecting. Those which offer a definite pest risk to this country should not be admitted in any quantity for any purpose. The weakness of inspection is fully realized but after all it is all that we have to depend upon save absolute embargoes, and I am convinced that plants can be admitted under competent inspection with no greater risk to this country than obtains under our present system.

As to the domestic quarantine situation, in general we are on a safe and sound basis. Our quarantines are more or less in the public view at frequent intervals through the medium of public hearings and otherwise so that changes are being more or less constantly made to meet changing conditions.

TREATMENT OF IMPORTED SPANISH GRAPES AND OTHER FOREIGN QUARANTINE DEVELOPMENTS DURING THE YEAR

By E. R. Sasscer, *Washington, D. C.*

The Fruit and Vegetable Quarantine No. 56 which governs the entry of fruits and vegetables from all countries became effective November 1, 1923. When this quarantine was promulgated it was the general belief, on the basis of observations made in the field, that the grape was immune from fruit fly attack; hence, provision was made for its entry under permit and subject to inspection at the port of first arrival. Within a month of the effective date of the quarantine, inspection of Spanish (Almeria) grapes in New York revealed the fact that certain lines were arriving infested with the Mediterranean fruit fly. Following this discovery all outstanding permits were cancelled and from that date to 1934 the Almeria grape has not been on the markets of the United States.

On April 19, 1934, the Bureau of Plant Quarantine announced that recent experimental work by the Bureau of Entomology of the United States Department of Agriculture had proved that all stages of the Mediterranean fruit fly in fruit can be destroyed if the fruit is subjected to the following treatment: "Cooling until the approximate center of the fruit in the package reaches a temperature of 30° to 31° F. and holding the fruit at that temperature for 15 days." Furthermore, storage tests with certain varieties of Vinifera grapes grown in the United States demonstrated that this treatment could be applied without danger of injuring fruit, provided the requirements of the treatment as to temperature were carefully followed. On the basis of the evidence secured, permits were issued authorizing the entry of Vinifera grapes at the ports of New York and Boston from regions in which the Mediterranean fruit fly occurs, subject to the treatment outlined. Additional safeguards prescribed in connection with the entry of grapes included the use of approved tight containers, the prompt repair of any broken containers found on the docks, transfer of the fruit from the docks to the refrigeration plants within 24 hours from the time of unlading, and limitation of the period of entry from October 1 to April 15.

The first shipment of grapes, consisting of 522 barrels (a barrel represents 46 pounds) arrived at Boston on October 1, and from that date up to and including December 12, a total of 158,073 barrels have entered at Boston and New York.

The treatment of the grapes is performed by privately owned cold-storage plants under the supervision of representatives of the Bureau of Entomology and Plant Quarantine. This supervision involves the keeping of inspectors on duty the full period the grapes are under treatment. To insure that the fruit is exposed to the required temperatures, numerous air and fruit thermometers are placed at strategic points in the room and are read every two hours, day and night, until the treatment is completed. The period required to effect the prescribed treatment from

the time the grapes are all stored in the cool rooms until the exposure is completed has ranged from 15 to 27 days. This period is influenced by the temperature of the grapes at the time storage takes place.

Briefly, there is abundant evidence that this method of safeguarding the entry of grapes has been a complete success, with a result that the markets of the United States are now open to certain foreign grapes which heretofore were excluded because of the pest risk accompanying the entry of untreated grapes.

Contrary to expectations, certain features of the foreign plant quarantine work have shown a distinct increase. Owing to the drought of this year, there has been an increasing demand for certain foreign products. The need for animal feed perhaps represents the greatest increase of foreign entries which has taken place during the present year. To illustrate, the total importations of cottonseed cake from foreign countries for the five-year period preceding July 1, 1934, amounted to 4,174,775 pounds, as contrasted with 27,184,438 pounds imported this fiscal year. The shelled-corn importations this fiscal year exceed those of the previous five years by approximately 10,000,000 pounds. In excess of 90 per cent of this corn arrived from Mexico, the remainder from Argentina and Manchuria. The apparent shortage of broomcorn in the United States this year has also resulted in a considerable increase in the imports of this product. During the five-year period preceding July 1, 1934, a total of 407 bales was imported, whereas during the present fiscal year 14,569 bales and 34,472 pounds have been imported. This broomcorn originated in Argentina, Hungary, Italy, and Mexico, and a considerable amount of that imported from the last-named country arrived in bulk. In passing, it may be noted that practically all of the shipments arriving from Europe have been infested with living European corn borer larvae, and that all shipments, whether infestation is noted or not, are given steam treatment as a condition of entry.

In considering the possibility of the entry of pests into the United States, much attention has been given to steamships as possible carriers, the infested products arriving either as cargo, ships' stores, or passengers' and crews' baggage. Numerous instances emphasizing this risk have come to light during the present year. To cite only one, a ship arriving in New York from Mediterranean ports was found to carry 1,150 passengers, 600 of whom were traveling third class. Twenty-two gunny sacks of fruits and vegetables were taken from the baggage of the passengers, 85 per cent of which was found in third-class baggage. The fruits intercepted included apples and quinces from the Azores, persimmons from Portugal, peaches, sweet limes, pomegranates, prickly pears, grapes, pears, apples, quinces, and green olives from Italy, persimons and pomegranates from Greece, and pomegranates from Syria. Ninety-five per cent of this contraband material was taken from trunks, suitcases, and other containers in which there were also wearing apparel, household linens, etc. Careful inspection of these fruits was not possible, but prior to their destruction the Mediterranean fruit fly was found in oranges, one lot of which showed about 25 per cent infestation and two lots of Sorbus apples which were 100 per cent infested. On the basis of the

examination made, it has been estimated that careful inspection would have resulted in the finding of from 1,000 to 5,000 living larvae.

Another important and continuing source of risk is in connection with fruits arriving in passengers' baggage on pullman cars from Mexico. From January 1, 1933, to December 1, 1934, 428 interceptions of plants and fruits covered by foreign plant quarantines have been made from passengers' baggage arriving through the port of Laredo, Tex. These interceptions include 13 known host fruits of the Mexican fruit fly, and from this material 10 interceptions of living fruit fly larvae were made. These were collected in mangoes, oranges, guavas, peaches, pears, and sweet limes.

Another avenue of entry that is becoming more important annually is the passenger airplane. Travel by air has brought us much closer to the tropics, with the result that infested fruit in passengers' baggage may leave a country in Central America and arrive in the United States within a day. Such pests as the following have been intercepted in baggage or mail arriving by this means of transportation: The citrus black fly, fruit fly larvae, the pink bollworm, and a number of other insects believed to be of lesser importance. The rapid progress made in air transportation and the increasing number of lines operating from foreign countries to the United States is in no small measure increasing the risk of introducing new insects and plant diseases.

Studies in the general field of foreign plant quarantine are constantly being carried on with a view of making these quarantines more effective for their intended purpose, relaxing the restrictions wherever this can be done consistent with safety to this country, or adjusting procedure to provide for simpler administration and for imposing a minimum of restraint on commercial movement.

Omitting a number of minor alterations and adjustments in regulations that do not appreciably affect the terms of the quarantines concerned, the outstanding changes made in 1934 in the 35 quarantines and regulatory orders enforced by the Division of Foreign Plant Quarantines are as follows:

In a revision of domestic quarantine No. 30, on sweetpotatoes and yams from Puerto Rico and Hawaii, effective October 10, 1934, an additional insect, the sweetpotato stem borer (*Omphisa anastomosalis* Guen.) has been included. At the same time the sweetpotato weevil (*Cylas formicarius*) has been dropped from this quarantine, not because of any change in attitude toward it as a pest, but because its removal from this Federal quarantine will allow freedom of quarantine action in the interstate field. It is noted also that the yam (*Dioscorea* spp.) has been taken out of this quarantine, since field inspections over a period of years have indicated that this tuber in these islands is not subject to attack by *Euscepes batatae*. As the result, the various species of *Dioscorea* may now be shipped to the mainland from both Territories under the inspection and certification provisions of other existing quarantines.

Owing to recent interest in the commercial movement of bagasse, the domestic and foreign sugarcane quarantines have been revised to bring this sugar-mill product definitely under restriction. The foreign

sugarcane quarantine was revised for this purpose effective October 1, 1934, and a similar revision of the domestic quarantine No. 16, affecting sugarcane from Puerto Rico and Hawaii, will come into effect on January 1, 1935.

A modification of the citrus nursery stock quarantine, No. 19, in 1932 permitted the entry of citrus seeds subject to disinfection, and another modification was made, effective September 1, 1934, confining the scope of this quarantine to 8 genera of the tribe Citrinae and thus releasing 27 other genera of the subfamily Citratae from their formerly prohibited status, and allowing entry to them under the Nursery Stock, Plant, and Seed Quarantine No. 37.

As stated by Mr. Hoyt, the entry of elm burl logs under the provisions of the Dutch Elm Disease Quarantine, No. 70, will be prohibited as of January 1, 1935. This quarantine became effective October 21, 1933, and since that date 11 shipments, involving 86 logs, have entered at the ports of Norfolk, Baltimore, and New York. Examination of these logs at the time of arrival revealed the fact that it appears to be impracticable to remove all of the bark, since bark was found on logs in 9 of the 11 shipments. Living *Scolytus* beetles were taken in this bark and sections of wood taken from some of the logs to the laboratory were found to be infected with the Dutch elm disease. This subject will be further discussed by Prof. R. Kent Beattie.

As a result of the restrictions placed by various foreign countries on the entry of fruits, vegetables, and nursery stock, including seeds, considerable additional work has been placed on the port inspection service. The number of shipments involving inspection and certification during the fiscal year 1934 exceeds all previous demands on this service. During that year, 7,222 shipments consisting of 2,720,474 containers were examined. These products were shipped to 53 foreign countries.

FURTHER NOTES ON CHEMICAL STERILIZATION AS A MEANS OF ERADICATING POTATO WART DISEASE FROM THE SOIL

By R. H. BELL, *Pennsylvania Department of Agriculture, Harrisburg, Pa.*

In reporting on this subject at the 1933 meeting of this group Mr. Hartman of our department offered a brief summary of potato wart investigations prior to 1927. He pointed out that soil sterilization was one of the first points of attack by investigators but while certain chemical and other treatments had proven effective, their cost or effect on plant growth was such as to make their use prohibitive. This failure to discover sterlizing agents of practical value, the determination that wart persisted in the soil after a lapse of nine years in potato culture—sixteen years at the present writing—and failure of efforts to develop an immune variety to replace our susceptible Rurals which represent over 90 per cent of our crop, left us in the position of facing a continuing quarantine or of eventually giving up all efforts to solve the wart situation.

Finally, our department decided to make one more attempt at a solution of the problem, and accordingly a program was set up in 1927, which among other things included a further study of chemical soil disinfectants. Of the several materials tested by 1932 one, ammonium sulfocyanate—developed as a chemical weed killer— looked promising, with sodium arsenite a second possibility. The cyanate was applied in 1932 to artificially inoculated plots at the rate of 1,200 and 2,000 pounds per acre. Duplicate 100 square feet plots (one set irrigated until planted) were treated May 15 and planted to susceptible rurals July 15.

Germination was slow and incomplete, and plant growth very much retarded throughout the season, resulting in low yields. A careful examination, however, failed to locate any wart on treated plots while check plots were uniformly warted. A recheck of these same plots in 1933, without further treatment, showed normal germination, plant development and yield, and continued freedom from wart in treated plots; whereas the checks showed 90 per cent infection. Also, additional artificially inoculated plots were treated with cyanate in the spring of 1933 (the sodium arsenite being dropped on account of cost and difficulty of handling), at the rate of 800, 1,600, 2,400, and 3,200 pounds per acre. The ill effect of the treatment on germination, plant growth and yield in these plots was in proportion to the amount of the application and similar, although less pronounced, to results secured in 1932. A slight amount of infection remained in the 800 pound plot but was absent in the 1,600, 2,400 and 3,200 plots. The 800 pound plot was immediately spot treated to eliminate the slight infection which had survived. In addition to the controlled tests with cyanate made in 1933, the project was extended to include an infected garden in one of our isolated areas. Treatment—2,000 pounds per acre— was applied April 10, and the garden planted to susceptible Rural Russets June 29, after an elapsed period of eighty days. Germination in this case was retarded about ten days but not harmed; plant development was above average, and when dug October 16—still quite green—the yield was at the rate of well over 300 bushels per acre. The most careful examination failed to reveal any indication of wart.

These experiences offered further encouragement, so that in the fall of 1933 twelve additional gardens in four communities, and comprising about three acres, were treated with cyanate at the rate of 2,000 pounds per acre, with the hope that the chemical would be sufficiently dissipated by spring to make planting safe. Also a new series of control plots was artificially inoculated and treated in the fall of 1933 at the rate of 1,600, 2,000, 2,400 and 3,200 pounds of cyanate per acre to simulate fall treatments in the field. These twelve gardens, and the one treated and planted in 1933 were all planted to susceptible Rurals during May, 1934, as were the control plots treated in the spring and fall of 1933.

For our 1934 planting operations we, therefore, had the four conditions:

A. Control plots treated the spring of 1933; B. Control plots treated the fall of 1933; C. One garden treated the spring of 1933; and D. Twelve gardens treated the fall of 1933; from which the following results were secured:

A. Control plots treated in the spring of 1933 with 800, 1,600, 2,400 and 3,200 pounds of cyanate per acre were planted to susceptible potatoes during May, 1934. Germination was normal in all cases, plant growth very luxuriant, and when dug October 15 the approximate yield ranged from 492 to 616 bushels per acre which was slightly higher than for corresponding checks. A plant by plant examination failed to reveal any wart in treated plots, while the checks showed mild infection.

B. Control plots treated in the fall of 1933 with 1,600, 2,000, 2,400 and 3,200 pounds of cyanate per acre were planted May 15, 1934. Germination was retarded in all but the 1,600 pound plots but yield was not seriously affected except in the 3,200 pound treatment where it was reduced approximately 40 per cent. No wart developed in any of this series.

The following table summarizes results secured from planting of series A and B:

PLOTS TREATED WITH CYANATE SPRING AND FALL OF 1933 AND PLANTED TO SUSCEPTIBLE RURAL POTATOES MAY, 1934

Plot	Cyanate pound per acre	Germination and plant growth	Infection	Yield bu. per acre
	Spring treatments			
1	800 liquid	Normal	None	508.2
2	1600 liquid	Normal	None	525.8
3	2400 liquid	Normal	None	598.0
4	3200 liquid	Normal +	None	615.7
5	800 chrystal	Normal +	None	546.8
6	1600 chrystal	Normal—	None	549.5
7	2400 chrystal	Normal +	None	611.7
8	3200 chrystal	Normal	None	492.3
11	Check	Normal	Yes	569.9
12	Check	Normal	Yes	519.1
	Fall treatments			
13	1600 chrystal	Normal	None	573.5
14	1600 chrystal	Normal	None	627.1
15	2000 chrystal	Normal	None	479.1
16	2000 chrystal	retarded 10 days	None	515.5
17	2400 chrystal	retarded 10–15 days	None	437.9
18	2400 chrystal	retarded 10–15 days	None	533.6
19	3200 chrystal	retarded 3 weeks	None	287.5
20	3200 chrystal	retarded 3 weeks	None	356.7

C. The garden treated in the spring of 1933 at the rate of 2,000 pounds of cyanate per acre was planted May 22, 1934 without further treatment. Germination and plant development were normal or better for the conditions involved. The yield was at the rate of 392 bushels per acre and a plant by plant examination failed to reveal any indication of wart.

D. Gardens treated in the fall of 1933. We furnished all seed and fertilizer and did the actual planting of these gardens during April 1934. The property owner was responsible for the plowing of the ground and cultivation of the crop during the growing season and in a majority of cases performed his part fairly well. In some cases weeds were allowed to get ahead of the crop, resulting in lowering of yields. All the digging was performed by our own employees who at the same time made a plant by plant examination for wart.

No trace of wart was found in ten of the twelve gardens. Thirty warted plants were found on a small low area in the eleventh (Wasco) garden comprising 4,000 plants, and one warted plant was found in the twelfth (Tucker) garden. One explanation we might offer for the small residue

of wart in these two gardens is the physical condition of the soil. Garden number eleven had stood in weeds and sod for at least fifteen years so that it is possible these heavy sods which could not be broken up thoroughly before treating, expecially in the low area where wart was found, prevented the cyanate from thoroughly permeating the soil mass. In the case of garden number twelve, we found a considerable quantity of trash of various sorts incorporated with the soil and it was in the vicinity of such debris that the wart was found. Immediate retreatment was applied in both cases.

In every garden germination was markedly delayed and in such portions of the garden that were low which permitted a concentration of the chemical due to drainage, no plant growth was possible. However, the plants that did grow became exceedingly vigorous, due in part to the fertilizing effect of the Ammonium in the chemical used as a sterilizing agent.

The results of the gardens treated the fall of 1933 and tested in 1934 are listed separately as follows:

OSCEOLA MILLS.

(1) James Garden.
Germination 98%. Delayed three weeks. Later plant growth excellent.
Yield—425 bushels per acre.
No wart found.

(2) Kontaske Garden.
Germination—Sec. (a) Germination 60%. Early injury very severe. Sec. (b) Germination 50%. Large areas were completely killed. In both sections the plants that survived the early injury developed very large healthy plants. Tubers very large.
Yield—197 bushels per acre.
No wart found.

(3) Churney Garden.
Germinations 90% but the patch was neglected. In some sections, the crop was reduced approximately 60% due to weeds. The sections free of weeds developed strong healthy plants.
Yield—approximately 190 bushels per acre.
No wart found.

(4) Gazak Garden.
Germination 95%.
Early injury delayed plant growth three to four weeks. The plot was cultivated and hilled in early summer but permitted to go to weeds later. This reduced the crop 25%. Plant growth in spite of weeds was excellent.
Yield—432½ bushels per acre.
No wart found.

SMITH MILLS.

(1) DeTrussi—Copenhagen Garden.
In Section (a), the high part of garden, the germination was delayed and some permanent injury noted. In this section the germination was 90%. In Section (b), germination was very markedly delayed. In one third of this section all plants were killed, one third had ninety per cent germination and the later plants were excellent. The other one third had a 50% germination and the plants were fair.
Yield—308 bushels per acre.
No wart found.

(2) Wasco Garden.
Germination 95%. Early growth slow, later growth fair to good. Garden very weedy in late season.
Yield—231¼ bushels per acre. The crop was badly injured by grub and wire worms.
Wart Reaction—In Section (a) 30 plants were warted. The balance of planting free. Seven tenths of one per cent infected. Each infected area was treated as dug with mercuric chloride solution (1–1000) applied at the rate of two quarts per square foot. In addition, the entire area infected was retreated with ammonium sulfocyanate at the rate of two thousand pounds per acre. This garden will be rechecked in 1935.

YATESBORO AND RURAL VALLEY.

(1) Solfchack Garden.
Germination 80%. Early germination very slow, delayed one month. Late growth fair to good.
Yield—428½ bushels per acre.
No wart found.

(2) Nikichik Garden.
Germination 80%. Early growth very slow. Late growth good to excellent.
Yield—681½ bushels per acre.
No wart found.

(3) Ziegler (Doliat) Garden.
Germination 75%. Early growth very slow, late growth fair. Patch quite weedy.
Yield—272¼ bushels per acre.
No wart found.

MOOSIC.

(1) Tucker Garden.
Germination—Average 40%. One half of garden killed by treatment.
Yield—140½ bushels per acre.
Wart Reaction. One hill found infected. This hill immediately treated with mercuric chloride solution (1–1000) at the rate of 2 quarts per square foot. In addition, the infected spot retreated with ammonium sulfocyanate at the rate of 2,000 pounds per acre.

(2) Fox Garden.
Germination 10%. Injury very severe, very few plants developed tubers at all. Total yield less than two bushels.
No wart was found.

SUMMARY

Fall treatment appears to be satisfactory but early injury has been as severe as that experienced by treating in April and planting eighty to ninety days later. Weather is likely to be a factor in this regard. In every case early injury was apparent but such plants as escaped developed excellent growth with the exception of the Fox Garden.

Old sod gardens appear difficult to treat successfully until they have been thoroughly plowed and perhaps cropped with buckwheat, oats, etc., then plowed and the seed bed prepared for application of treatment.

Both the Wasco Garden of Smith Mills and the Tucker Garden of Moosic had remained unplanted to any crop for fifteen years.

Many phases of the work remain to be investigated, however, and until we know more of the effect of the chemical action in various soils, the effect of moisture, (water capacity) etc., the problem must be viewed as being in a strictly experimental stage.

Present plans call for a recheck of gardens treated in 1933 and if facilities permit, additional gardens will be treated the spring of 1935.

Incidentally, I might mention that in conjunction with the soil sterilization work, we have changed our quarantine so as to allow planting under permit of varieties other than immunes in the four quarantine areas where gardens have been treated. During the past season this involved summer and digging inspection of 543 gardens and other plantings. Digging inspection was the most difficult part of this phase of the program, necessitating a fixed schedule of digging dates covering a period of about six weeks.

Fortunately, no wart was found in any of these 543 plantings which is further proof of the thoroughness of the original wart survey. However, six other gardens originally designated as suspected cases were planted with susceptibles this year and one of them developed infection after a lapse of sixteen years in planting of susceptible varieties. This, together with the infection found in two of the treated gardens, would seem to pretty well explode the theory of elimination of wart by starvation, at least so far as potato culture is concerned.

DUTCH ELM DISEASE ERADICATION IN THE UNITED STATES

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This paper is presented before the Quarantine Section because the Dutch elm disease eradication program includes many insect as well as disease problems. An attempt has been made to include as much information on the principles and policies involved in the program as can be crowded into a short paper. The report includes: (1) A brief history of the European situation, the introduction into this country, and the distribution of the disease in the United States; (2) a short review of the work on the fungus, the pathological reaction of the diseased tree to this parasite, and the role that insects may play in the epiphytotic nature of the disease; (3) a statement of the objective, the scouting-eradication methods, and the results of the eradication program; and (4) an outline of the projected work of the governmental control agencies and the manner in which entomologists and plant pathologists can assist in the eradication of the Dutch elm disease in the United States.

The Dutch Elm Disease in Europe and the United States.—The place of origin of the Dutch elm disease has not been determined. By 1920 many reports of a serious disease of elms in Belgium, northern France, western Germany, and The Netherlands had appeared in the public press. It appears that by this time the disease had become well established in this general area. A Dutch pathologist, who made a careful study of the dying elms, found that a fungus which she named *Graphium ulmi* was the cause of this new disease. It is because of this early atten-

tion of the Dutch scientists that this elm wilt has been popularly called "the Dutch elm disease." The fungus has since been named *Ceratostomella ulmi* (Schwarz) Buisman.

By 1926 the disease was officially reported at locations in France and the western two-thirds of Germany, and in 1927 in southern England. This represents an area extending about 750 miles east and west and 550 miles north and south. The latest reports indicate that the disease is present in Portugal, central Italy, Austria, Roumania, western Poland, Germany except Prussia, and middle England. This area extends about 2,000 miles east and west and 850 miles north and south. It is of interest to note that the disease has apparently not spread northward into Denmark, Sweden, Norway, and Scotland. There are no reports of a concentrated effort to eradicate the disease on the Continent.

The Dutch-elm-disease fungus was probably brought into this country in elm burl logs imported from Europe as early as 1925. Such logs are known to have entered at New York City, Baltimore, Norfolk, and New Orleans, and been shipped to or through Cleveland, Cincinnati, Indianapolis, Chicago, Louisville, Knoxville, Kansas City, and other cities. Some of the logs in the shipments that were intercepted bore evidence of the Dutch elm disease and bark beetles. Federal Quarantine No. 70 now prohibits the entrance into this country of all elm material that may carry the fungus and insects.

The disease has gained a strong foothold in New Jersey, New York, and Connecticut around the port of New York City, where over 7,600 infected trees have been found, all located within 50 miles of this port. Infected trees have been found in six other areas as follows: Cleveland, 10; Cincinnati, 1; Baltimore, 1; Indianapolis, 4; Old Lyme, Conn, 1; and Norfolk, 1. With the small scouting force that has been available it has been impossible to insure the finding of all diseased trees in these areas and in other areas that imported logs have entered.

THE DUTCH ELM DISEASE AND INSECT VECTORS.—The fungus *Graphium ulmi*, which causes the Dutch elm disease, is known to be parasitic only on elm and the closely related Zelkova. When introduced into the cambial region and outer sapwood of living trees, it causes the formation of gums and tyloses in the water-conducting vessels. When the water flow is critically reduced or stopped, the leaves of the affected branch or tree wilt and may die. The time from the entry of the fungus into the tree until the tree is generally diseased may be only a few weeks or several years, depending upon as yet undetermined conditions.

Any list of symptoms that adequately describes the Dutch elm disease also includes symptoms of other elm diseases. The most conspicuous and definite external symptom is the wilting, and sometimes yellowing and dropping, of the leaves of an infected branch or entire tree. A brown discoloration, which in cross section appears as dots or a ring is produced in the current or recent annual ring. Usually short brown streaks in the cambial region can be seen when the bark is peeled off. Verticillium wilt and Cephalosporium die-back produce symptoms so similar that these diseases cannot be definitely distinguished from the Dutch elm disease by field tests.

Following the death of a tree affected with Dutch elm disease or the transfer of the fungus to dead material, *G. ulmi* may grow abundantly as a saprophyte in insect tunnels, in cracks developed in the wood and bark, and to some extent on the ends of broken branches. Insects, principally bark beetles, which emerge from infected material may carry the fungus on the inside as well as the outside of their bodies. The engraver bark beetles, that feed on healthy elms, are of particular importance as insect vectors, for as they chew through the bark and into the wood in the crotches of elm twigs, they may introduce the fungus into the tree. The number of possible vectors cannot be limited, however, to those that feed upon healthy bark and wood. All insects that emerge from diseased trees may carry the fungus and, during egg laying, introduce it into dead trees or dead branches in otherwise healthy trees. Furthermore, since the vector-fungus relationship is apparently physical and not biological, all insect and other agencies associated with elms may be important factors in the spread of the disease.

The smaller European elm bark beetle, *Scolytus multistriatus* Marsh., which is a known vector of the Dutch elm disease in America, has been collected from the general area east of Harrisburg, Pa., north of the New Jersey-Delaware State line, and south of the Massachusetts-Vermont State line. There is evidence that this area may include at least two infestations, one reported at Cambridge, Mass., in 1909 and another, perhaps older one, at New York City, and that there may be a Scolytus-free area between these two infestations. In this country two generations and possibly three occur in a year. *S. scolytus* Fab., which is considered the more important vector in Europe, is not known to be established in this country, although it has been intercepted at various ports. The American elm bark beetle, *Hylurgopinus rufipes* Eichh. with habits somewhat similar to those of *Scolytus*, occurs throughout the northern elm area in the United States. Other insects also may be involved in the epiphytology of the Dutch elm disease.

Objectives and Methods of the Eradication Program.—The immediate control and ultimate eradication of the Dutch elm disease in the United States is the primary objective of the governmental agencies engaged in the work. To accomplish this objective, the early location and prompt eradication of all material infected with *G. ulmi* is deemed essential. The final cost of the project and the number of elms that are lost before the disease is eradicated will depend largely upon the timeliness and the thoroughness of the work each year. At the present time State funds and to some extent the resources of the C. C. C. are being used. Funds have been allotted from the P. W. A. for this purpose, but the money is not available at this time.

Scientific facts that have a practical application as well as methods found effective in other disease eradication projects have been used as the basis for the field work. Scouts who are familiar with the external and internal symptoms of the disease examine all the elms in a designated area three times a summer. In order that this serious disease may be distinguished from other wilt diseases of elms, the scouts are required to sample and collect for laboratory diagnosis six specimens from each

suspected tree. A card for each tree is made out to show its location and condition and to furnish other information for the eradication crew if the tree is found to have Dutch elm disease.

The Dutch Elm Disease Laboratory is equipped to make cultures of all elm material suspected of being diseased. If the trees are infected with this disease, the *Graphium* fungus will grow in the cultures and usually can be identified in about four days. A list of all such trees, together with a certification that they have the Dutch elm disease, is put into the hands of the proper State official. He immediately seeks the cooperation of the owner for the removal of each tree in which the presence of *Graphium* has been confirmed. If funds are available, the State or Federal control agency then proceeds to effect the removal of the trees at no cost to the property owners. In many instances local shade-tree commissions have assumed the responsibility for the removal of diseased trees on public property. Otherwise, trained men hired by the government or commercial organizations under contract perform the work. Because the wood from these trees is infected with the fungus that causes the disease, and is or may become infested with vectors of the disease, it must be burned immediately.

Inasmuch as the bark beetles, particularly *S. multistriatus* and *H. rufipes*, are considered important agencies of spread, the diseased trees should be located and destroyed before these beetles emerge. A serious delay in this work has nearly always existed because funds have been tardy in arrival and insufficient in amount. At one time in May 1934 the removal work was practically up to date, with only five confirmed diseased trees in New York standing. The conditions during the summer and at present are not so favorable, as over 1,200, or about 16 per cent, of the confirmed trees, largely in New Jersey, are still standing. All the known diseased material in the small outlying areas was promptly destroyed.

Program for Future Work.—With the funds now available, steps are being taken to remove immediately all the diseased trees that have been located. It is well recognized that dead and dying elms in the infected area may harbor the *Graphium* fungus as well as many possible vectors of the disease. Consequently, a concerted effort is being made to locate and removed from the disease area and a small surrounding area all these menaces to healthy elms. Field counts indicate that there are as many as 160,000 of these elms which should be removed before the scouting season starts in the spring.

If there are adequate funds, the regular scouting work should begin about May 15, in the major infection areas. In general, this same type of work is planned for the outlying areas where diseased trees have been found and where imported logs have been traced.

The area that will be assigned to systematic scouting is strikingly small when compared to the whole area in which the Dutch elm disease may exist. The assistance of entomologists and plant pathologists, as well as other individuals, in locating diseased trees in this large area must be depended upon. The entomologists can also cooperate by collecting and studying all insects that are associated with elms. Such active

participation in the scouting work and collection of data on possible insect vectors will be a definite contribution to the eradication of the Dutch elm disease in the United States.

SUMMARY.—More than 7,600 trees affected with the Dutch elm disease have been found in the major infection center in New Jersey, New York, and Connecticut. These trees are confined to an area within 50 miles of the port of New York City. Isolated infected trees have been found in Cleveland, Cincinnati, Baltimore, Indianapolis, Norfolk, and Old Lyme, Conn.

Since the discovery of the Dutch elm disease in this country, Federal and State agencies have engaged in an eradication program. The timely location and prompt removal of trees showing evidence of *Graphium* fungus form the essential points of this program. Inasmuch as the smaller European elm bark beetle, *S. multistriatus*, is considered an important agency of spread of the disease, an attempt has been made to remove the diseased trees before the insect emerges. However, owing to insufficient funds, many diseased trees discovered early in the season are still standing.

Plans for eradication work in the infected area this winter include the removal of all the known diseased trees as well as the dead and dying elms which may harbor the Dutch elm disease fungus and its many insect vectors.

RESEARCH DURING 1934 ON *CERATOSTOMELLA ULMI*, THE CAUSE OF THE DUTCH ELM DISEASE

By R. KENT BEATTIE, *Principal Pathologist, Division of Forest Pathology, Bureau of Plant Industry, United States Department of Agriculture*

At your 1933 meeting, I reported to you the isolation of the Graphium form of *Ceratostomella ulmi*, the causal organism of the Dutch elm disease, from burl elm logs which had been imported from Europe and had arrived at the ports of Baltimore, New York, Norfolk and New Orleans. I suggested the probability that the disease had been introduced into the United States through previous shipments of these logs. The work during 1934 has tended to confirm this log-carrier hypothesis.

Two additional trees were found during 1934 at Cleveland, Ohio. They stood about 16 or 18 inches apart and perhaps are really but a single tree. Considerable discoloration occurred in the 1929, 1930, 1931, 1932, 1933, and 1934 annual rings, and Graphium has already been cultured from the 1931, 1933, and 1934 rings. Studies have not yet been completed in regard to the remaining rings. The trees stood in the part of Cleveland where infected trees had been found in previous years and had undoubtedly been seen during most of the years since 1930 by men searching for the Dutch elm disease. There was little or no evidence that limbs had died before 1934. It is therefore logical, to assume that these two trees became infected in 1929 and that they carried the infection without visible external symptoms for five years, from 1929 until the fall of 1934, when they wilted. Like the other Cleveland trees these

trees stood not far from railroad lines which hauled imported elm burl logs from the maritime ports of first arrival to the veneer factories utilizing them.

In 1934, four trees infected with Graphium were found in Indianapolis, Indiana. All were within half a mile of a veneer factory which has been a prominent importer of elm burls from Europe; one was just across the street from the factory. Of the four trees, one showed Graphium in the 1926, 1929, 1931, 1933, and 1934 annual rings; a second in the 1928, 1929, 1932, 1933 and 1934 rings; a third in the 1929, 1933 and 1934 rings; the fourth tree, which was nearly dead, perhaps from other causes, showed Graphium in the 1934 ring only.

All the evidence accumulated to date leads us to believe that Graphium may move from one annual ring to those of succeeding years, but while more study is needed on this point, we have no evidence yet that the disease moves from an infected ring to those of preceding years. In other words, from the point of view of a trunk cross section it moves centrifugally but apparently not centripetally. On this assumption the tree which showed Graphium in the 1926 ring has therefore probably been infected for eight years and is the oldest infection yet discovered in America.

There are several possible explanations of the conditions found at Indianapolis. The trees may represent independent infections resulting from log importations in three different years. There may be present in the region a few undiscovered Scolytus beetles transmitting the Graphium but the vicinity is believed by representatives of the Bureau of Entomology and Plant Quarantine to be free from these beetles. Some other as yet unknown carrying agent may be operating at Indianapolis.

In 1934, one Graphium-infected tree was found at Norfolk, Virginia. This tree stood near the street which leads from the unloading piers to the local veneer-utilizing plant. It is the street along which imported logs were hauled. The tree was in the final stages of dying when discovered in the fall of 1934. Graphium occurred in the 1930, 1931, 1932, 1933 annual rings and was very abundant in the 1934 ring. The 1929 ring showed some discoloration but Graphium could not be cultured from it.

The evidence that the causal organism of the Dutch elm disease was introduced into the United States from Europe by means of elm burls imported for the cutting of fancy veneer may now be summarized as follows:

Graphium has been isolated from logs intercepted at four maritime ports of arrival.

Over 7500 diseased trees have been found around the arrival port, New York City; one tree has been found at the arrival port of Baltimore; and one tree at the arrival port of Norfolk.

Ten infected trees have been found at Cleveland and one at Cincinnati, Ohio, near railroads which hauled imported elm burls from the maritime ports of arrival to veneer factories in the Middle West.

Four trees have been found at Indianapolis, Indiana, near a veneer factory utilizing imported logs.

But one Graphium-infected elm is known in the United States whose presence cannot be explained by our present knowledge of elm log entry and movement. This tree was found by the scouts of the State of Connecticut in the town of Old Lyme near Long Island Sound on the east side of the mouth of the Connecticut River and 70 miles from the New York City infection area. Explanation of this case must await further information as to the means of spread of Graphium.

A search for other possible means of entry of this fungus into America has revealed the fact that for many years it has been customary for certain potters in Staffordshire, England, to ship cheap dishes in crates instead of in casks. These crates are made of sticks from which the bark has not been removed. There seem to be no favored woods but anything available is used. Among crates of this type examined in New York fifteen were built in part of elm sticks. Five of the fifteen showed brown streaks in the young wood and contained living larvae of *Scolytus multistriatus* as identified by representatives of the Bureau of Entomology and Plant Quarantine. Attempts to isolate Graphium from these sticks were unsuccessful but other fungi were obtained and are being studied. Nevertheless this finding suggests another possible method of the introduction of the Dutch elm disease from abroad. Sufficient progress has been made in checking such importations to show that these crates have been coming for many years and that their principal ports of arrival are New York and Boston. Many of the crates are unpacked at Boston and New York and are discarded there, but certain of the original packages have been sent to other points in the United States.

The expanded campaign of the United States Department of Agriculture and of the States of New Jersey, New York and Connecticut during 1934, as well as the aroused interest of people everywhere in their elms greatly increased the identification work of the Division of Forest Pathology. A new laboratory equipped for various lines of research on the Dutch elm disease was established at Morristown, New Jersey. During the year specimens for cultural identification from 16,872 suspected trees were received. From 49% of these trees Graphium was isolated; from 33% a species of Cephalosporium; from 4% a Verticillium; and from 14% miscellaneous or unidentified fungi and bacteria. Evidence was also secured indicating certain masking effects of one fungus upon another in culture and an extensive series of studies of this masking effect in mixed cultures is being made to improve cultural identification methods.

During the year, Graphium was grown saprophytically under laboratory conditions on unsterilized cross sections of the wood of 22 American species of trees, including such common trees as maple, beech, and oak. Other species of woods are being tested. Such saprophytic growth on woods other than elm has not yet been found in nature. Since these results were secured under the very special conditions which obtain in the laboratory, the significance of these findings is not yet apparent.

The scope of the work being done at the Morristown laboratory is indicated by the following studies now under way:

Methods of detecting diseased trees in the field by the observation of external symptoms, by twig sampling, and by trunk sampling are being developed.

A comparative study is being made of the elm wilt diseases known to exist in America in an effort to find diagnostic characters suitable for use in their field separation and the significance of these diseases in the Dutch elm disease problem.

The character of the epidemic spread of the Dutch elm disease under American conditions is being investigated. The environmental conditions under which elm infection by Graphium takes place are being studied in detail.

A more exact knowledge of the movement of the fungus in the tree and of its means of passage from ring to ring in the wood is of importance in the determination of the age of the various infections in this country. Studies to this end are under way.

A study is being made of the survival of Graphium in dead elm wood and the effect of the presence of other fungi upon this survival.

An attempt is being made to find an effective and satisfactory means of killing the stumps of felled Graphium-infected trees and of killing the Graphium in the stump. The stumps of felled diseased trees frequently sprout and show Graphium in the sprouts.

The host range of the fungus is being determined by the assembling and inoculating of elms and related plants. A search is thus being made for resistant elm species and resistant elm relatives. There are about 130 species in the family Ulmaceae.

Studies are being made of the possible heterothallism of the fungus, of the strains present in America, of the production of the perithecia of the sexual stage, *Ceratostomella ulmi*, in America and of the possible relation of these perithecia to the spread and overwintering of the disease in America. In America these perithecia have not yet been found in nature though they have been produced in laboratory cultures. In Europe they are found on the surface of the bark and would if present here seem to offer new possibilities of distribution of the disease by many carriers now excluded.

A mycological study is being made of other Graphium and Graphium-like species found on elm and their possible parasitism and relation to the Dutch elm disease problem are being determined.

A study of Graphium as found on possible insect carriers in the infected area is under way. This study is being made in cooperation with the Bureau of Entomology and Plant Quarantine and supplements the studies of that Bureau on the insects involved.

Birds are possible carriers of the Dutch elm disease and their relation to the problem is being investigated.

Such a program of work indicates how complicated is the problem which this elm-destroying fungus presents. On some of these questions there are European results and experience, but in all cases these need checking under American conditions. It is to be hoped that the results obtained will not only help to elucidate the Dutch elm disease but will also throw some light on the fundamental problems of forest pathology.

THE WISCONSIN RECIPROCAL NURSERYMEN'S LICENSE

By E. L. CHAMBERS

Attempts to get officials of forty-eight states to agree on a uniformity measure of any kind is quite an undertaking in these times and agreeing upon a model nursery inspection law seems as far away today from the goal as ever. Despite our good intentions and gradual progress resulting from strenuous effort put forth at thirty-two just such annual meetings of horticultural inspectors as this one, we still find ourselves unable to adopt a definite uniform policy relative to non-resident nurserymen's license fees. This is not difficult to understand when we consider the fact that the state inspectors cannot very well write their own inspection laws. If we could and did, the results would be different.

In 1925, when the hope of getting all of the states to agree upon certain definite uniform regulations, was recognized as still being very remote, the National Plant Board, you will recall, was organized to facilitate studying these problems. Under this plan the states were divided into four regional groups or plant boards which in turn included states having problems more or less in common. At that time one of these groups, the Central State's Plant Board consisting of the thirteen north central states, in its attempts to work out uniform regulations, appointed a committee to study the matter and make recommendations. In 1928 our Plant Board meeting at St. Louis adopted the recommendations of this committee on uniform requirements for the interstate movement of nursery stock. The officials of these various states were in agreement that all incoming nursery stock be free from injurious insects and dangerous plant disease and that it be accompanied by a certificate of inspection of the state of origin. Practically all of these states require outside nurseries to file duplicate copies of their valid certificate of inspection with the state inspector of destination state. At that time *three* of the thirteen states required outside nurserymen to pay a registration fee. All of the inspectors of the several states were in agreement that the practice of charging non-resident license fees should be discouraged and the group went on record recommending discontinuance of the practice at the first opportunity conditions would permit. The following years have found the Legislatures of our various states looking about for additional sources of revenue and we now find five out of our group of thirteen states requiring non-resident license fees ranging from one dollar to twenty-five dollars each. In some states, we are told, the underlying purpose of this out-of-state fee-charging practice is to secure funds for carrying on the inspection. In Wisconsin all fees collected are turned into the general funds through the State Treasurer leaving very little incentive to collect them especially when it requires an expenditure of about thirty dollars to collect ten.

Since the nurserymen of Wisconsin do very little shipping of nursery stock to other states compared with the amount shipped into the State, our nurserymen felt that they were being discriminated against in being required to pay a license for doing business in a State which in turn was

doing a much greater business in Wisconsin without having to pay a license. It appeared that the purpose of some of these non-resident license fees was probably nothing more than a masked tariff. For a number of years the matter of adopting a reciprocal license in Wisconsin was considered but each time we were discouraged because of the opinions secured from various sources that such a law would be unconstitutional. The matter was brought before the 1933 Legislature when the Attorney General's office rendered the decision that in their opinion the proposed law would be constitutional and consequently the law was enacted as follows:—

"(a) Non-resident nurserymen and dealers desiring to solicit orders for nursery stock in the state, shall file a certified copy of their home state certificate with the entomologist of the state, and shall then, upon complying with all other provisions of sections 96.33 to 96.48, and all rules and regulations promulgated thereunder and upon payment of the registration fee of ten dollars, be entitled to a certificate permitting such persons to solicit orders for nursery stock in this state.

(b) Notwithstanding the provisions of paragraph (a) of this subsection, the commissioners of the department of agriculture and markets may enter into reciprocal agreements with the responsible officers of other states under which nursery stock owned by nurserymen or dealers of such states may be sold or delivered in this state without the payment of a Wisconsin registration fee, provided like privileges are accorded to Wisconsin nurserymen or dealers in such other states, and provided, further, that the commissioners shall find that such other states before issuing their certificates, require inspections equal to those required under the Wisconsin law.

(c) If any of the exemptions provided for in paragraph (b) of this subsection shall be held invalid by any court of competent jurisdiction, the class or classes held to be invalidly exempted shall forthwith become subject to the provisions of paragraph (a) as if no exemption had been provided for. If any provision of this section or the application thereof to any person or circumstance is held unconstitutional, the remainder of this section and the application of such provisions to other persons or circumstances shall not be affected thereby."

The law, as you will note, was so worded that should anyone attempt to declare the reciprocal feature unconstitutional, there would be nothing gained in so far as paying a fee was concerned since the law provides a non-resident license fee of ten dollars and provides that should any exemption be declared invalid that the nurserymen would forthwith become subject to the provisions of paragraph (a) as if no exemptions had been provided for.

The officials of the State Department of Agriculture and Markets in Wisconsin have always been, and still are, opposed to non-resident license fees, and adopted this policy of charging a non-resident fee on the reciprocal plan in an attempt to discourage the practice of charging such fees in other states. The effects of this Legislation have been very gratifying. We have received letters of protests from the larger nurseries in the several states which have been requiring licensing of Wisconsin

nurserymen for a number of years, voicing their disapproval and assuring us that they were now opposed to their own state charging for a license and would use their influence to have the law changed. We believe that charging for a non-resident license fee does no one any good and in fact hurts everybody. It naturally would increase the cost of handling nursery stock and consequently the price of shrubs and trees to the customer. It makes the usual practice of free exchanges of small surplus amounts of stock between nurserymen of various states unprofitable and it represents a greater cost to the state attempting to collect the fees than they are able to realize from such revenue. If one nurseryman is required to pay a license fee, it is only fair that the state use all of its powers to see that every nursery doing business in the state pay a similar license. The only way that his can be effectively done is by having inspectors constantly check on shipments of nursery stock coming into the state and hold up any shipments originating from nurserymen who have not paid their license fee.

During the past year all out-of-state nurserymen doing business in Wisconsin, some 350, were sent a copy of the law and urged to take out their license promptly in order to be ready for the shipping season. Those from states in a position to enter into a reciprocal agreement filed a copy of their valid certificate promptly and 313 were issued their license without paying any fee. Since very few of the remainder subject to a fee applied for their license, it was necessary to write them two other letters calling their attention to the fact that any shipment intercepted would either be destroyed or returned to the sender, as our law provides. More than one-third of the out-of-state nurserymen paying licenses did not pay their fee until their shipments were actually held up and they were written and requested to advise disposition.

Since quite a number of the out-of-state nurserymen who did not take out a license have been exchanging nursery stock with Wisconsin nurserymen and their names have been furnished us by our nurserymen as sources, we are now at work checking up on the shipments made during the season by these nurserymen. Any whose shipments were not intercepted and from whom our nurserymen can show evidence that shipments were made to them, will be billed for the amount of their license fee and, of course, will not be allowed to make further shipments into Wisconsin until they have made payment. The procedure to follow will be, of course, to notify the carriers that shipments can not be accepted for delivery into Wisconsin from certain firms until they have compiled with the state nursery inspection regulations.

While frequent terminal inspections are made to satisfy us that we can depend upon the inspection service and the ability of certain out-of-state nurserymen to properly sort out visibly infested stock, we designate our license fee for this purpose as a registration fee only. Since we make from two to five inspections of all of our dealers amounting last spring to 419, handling nursery stock to see that all trees and shrubs are being stored and delivered in reasonably satisfactory growing condition and have an inspection tag attached, we have a pretty good idea of what we can expect from individual nursery firms.

The law having only been in effect since the 1934 shipping season, only a limited report can be made on its success to date. During the inspection season of 1932–33, just prior to this reciprocity law becoming effective, forty-seven nurseries were issued non-resident licenses gratis from states requiring a license of our own nurserymen. Of this number thirty-seven paid the ten dollar license fee required under our reciprocity law in 1933–34. If the law will have the effect of discouraging non-resident license fees or eliminating them through reciprocal arrangements, we will feel that the purpose of the law has been achieved.

THE JAPANESE BEETLE OUTBREAK IN ST. LOUIS, MO., AND ITS CONTROL

By C. W. STOCKWELL, *Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture*

Early in February 1934 the Missouri Department of Agriculture reported to the Bureau of Plant Quarantine that Japanese beetles had been collected in St. Louis during the summers of 1932 and 1933.

An immediate investigation was made of the reported infestation. Detailed inquiries disclosed that two Boy Scouts interested in collecting insects caught six or eight Japanese beetles in the back yard of their home at 3663 Lierman Avenue, St. Louis, late in June 1932 and caught, three additional specimens in June 1933. The boys were unaware of the identity of the insects until they were later shown in connection with a paper presented at a meeting of the St. Louis Entomological Club. Interviews with those familiar with the recovery of the beetles and their subsequent identification served to confirm the circumstances under which the collections were made. Accordingly, plans were made thoroughly to scout and trap the locality surrounding the property where the finds were made, as well as other sections likely to harbor the insect.

Upon conclusion of the preliminary inquiries in St. Louis, 1,600 Japanese beetle traps were shipped to that city for storage until the probable date of beetle emergence. By mid-June arrangements were completed with State and City authorities for placement and maintenance of the traps. An experienced trap supervisor was sent to St. Louis from the Japanese beetle headquarters at Harrisburg, Pa., to direct the season's activities. There were also sent from Harrisburg two experienced Japanese beetle scouts. These men made a systematic survey of all nursery and greenhouse establishments in St. Louis and within a radius of 10 miles of the city to determine whether or not beetle infestation might have become established on or near such premises. All such scouting was with negative results.

On June 19 placement of traps began in the locality where the reported beetles had been collected. One or more traps were placed on every property in the vicinity. In more distant blocks the traps were set at less frequent intervals. On the day the first traps were placed, five Japanese beetles were trapped. This definitely proved that there existed

an established infestation in the city and that beetles had already begun to emerge. Each succeeding day, as additional traps were put into operation and inspection began of those previously set, beetles in increasing numbers were captured. Maximum captures were made from July 2 to 10, inclusive. The largest daily catch was 220 beetles trapped on July 6. Daily recoveries diminished after July 10. Only 21 beetles were caught during August. The last day's catch, consisting of 2 beetles, was made on August 21.

As the extent of the infestation and abundance of the insect became apparent, the need for additional traps was evident. This need was particularly acute because of the rapid disappearance of the adult beetle and the necessity from a control standpoint of locating every isolated infestation in the community. To supplement the original supply of 1,600 traps, 1,000 additional were forwarded to St. Louis about the middle of July. These were scattered throughout the sections of the city not previously covered. Two hundred traps were also removed from sections that had not disclosed beetles and relocated in untrapped districts of the city.

Traps were set at 2,816 different points in the city. A total of 1,351 Japanese beetles were trapped. Practically all of the recoveries were made in a more or less continuous area comprising 117 blocks. Outside this infested zone, only 6 beetles were caught. Two of these were trapped at the Marine Hospital grounds, approximately 1 mile southeast of the main area. Four beetles were also captured at distances of from 2,000 to 7,000 feet northwest of the main area. The heaviest concentration of beetles caught in any one block was 94. These were captured in a section only three blocks distant from the yard in which the original 1932 collection was made.

Practically all of the infested territory is residential, with a few business blocks and occasionally blocks containing numerous vacant lots overgrown with weeds. In general the residence properties are well kept. Despite the drought of last season, lawns and flower gardens were in good condition, since the home owners supplied plenty of water to keep up soil moisture. These conditions are also most favorable for Japanese beetle survival, since they provide ideal soil texture for oviposition and an abundance of foliage for adult feeding.

Various considerations made it advisable that the best practices in soil treatment be employed immediately to destroy so far as possible the larval population resulting from this summer's oviposition. St. Louis is far removed from other points of infestation, being approximately 850 miles west of the generally infested area. The season's trapping evidenced an established infestation in an extensive residential area affording favorable environmental conditions for the insect's increase and spread.

Plans for a comprehensive treating program were prepared and immediate steps taken to secure funds necessary to apply lead arsenate to all blocks in which beetles had been trapped, plus a safety zone surrounding these areas. Within a few weeks of the conclusion of the season's trapping program, Federal funds were made available by Executive Order for applying the treatments. Funds were also allotted by the

Missouri Relief and Construction Commission and by the City of St. Louis for employing labor and for other necessary expenditures. Arrangements were made for an immediate purchase of 250 tons of dry lead arsenate for delivery at St. Louis in the shortest possible time. To secure this quantity of lead arsenate it was necessary to purchase from firms in many distant sections of the country. Experienced men were sent from the Harrisburg, Pa., field headquarters to supervise the work and operate the ten Federally-owned high-pressure sprayers also sent from Harrisburg.

City departments of St. Louis supplied park sprayers, fire-engine pumps and operators, trucks, hose, and other equipment necessary for the work. Office space, watchmen, and permission to close streets while the work was in progress were among the facilities supplied by the cooperating agencies. The Missouri Department of Agriculture served notices on all property owners and tenants, setting forth facts regarding the treatments and requesting cooperation in aiding the work.

Actual application of the soil insecticide began on September 26 and was completed on November 8. The lead arsenate was applied at the rate of 1,000 pounds per acre of treatable ground. The number of men employed varied from day to day, with a maximum for any one day of 177. The largest area covered by the crews in a single day was 18.9 acres. In all, a total of 440 acres received lead arsenate application at the designated rate. Approximately 1,400,000 gallons of water from city hydrants was used in applying the lead arsenate and washing it into the ground.

Ideal weather conditions prevailing throughout the period during which work was in progress, contributed greatly toward its successful completion.

Fullest cooperation was received from the City of St. Louis and the State of Missouri, as the officials concerned are most desirous of holding the insect within its present bounds and reducing its numbers to a minimum. Very little opposition was encountered from the persons whose premises were treated. There was a spirit of general cooperation.

A Missouri State quarantine is now effective restricting the movement of likely carriers of the beetle to points outside the infested zone. State inspectors in St. Louis enforce this regulatory order.

An even more comprehensive trapping program is planned for the summer of 1935, in anticipation that some beetles will survive the treatment already applied. Seventy-six hundred traps have been placed in storage in St. Louis for placement there next June. These will afford an opportunity for a very thorough survey of the conditions of infestation in the entire city and its environs. Every effort is being made by the Federal and Missouri Departments of Agriculture and the City of St. Louis to suppress this infestation and reduce to a minimum all possibilities of further increase and spread.

COURT PROCEEDINGS AFFECTING PEST CONTROL LEGISLATION

By S. B. FRACKER, *Washington, D. C.*

In several statements prepared by the solicitors of the U. S. Department of Agriculture (6), by Mr. Strong (4, 5), and by the author (3), information has been given for the guidance of plant quarantine officers as to court decisions affecting pest control operations. These papers have heretofore been confined to the general principles concerned, the constitutionality of the statutes, and conditions under which and the extent to which courts will review and rule on pest control orders issued by administrative officers. At the meeting of this Association last year, the author discussed primarily those court rulings under which it was shown that administrative orders are final and not subject to court review unless they are either unconstitutional, not supported by statute, based upon mistake of law, arbitrary, unjust, or unreasonable.

The purpose of the present paper is to deal not with general principles but with the particular types of court procedure which plant quarantine officers may and do use in connection with the enforcement of necessary pest control measures, as well as those proceedings under which aggrieved parties attempt to prevent the operation of pest control regulations when they feel that their own interests are adversely affected.

Dickinson (2) has outlined five ways in which administrative action can come before the courts for review. These are (1) Civil suits against officers as private individuals; (2) Proceedings instituted by officers to enforce their administrative orders, including criminal prosecutions for the non-observance of such orders; (3) The extraordinary writs known as mandamus, certiorari, habeas corpus, and injunction; (4) Direct appeal from an administrative order to the court under procedure prescribed by statute; and (5) Suits by administrative bodies for the expense of executing an order after its non-observance by the person to whom it was directed.

Pest control legislation appears to have been before the courts under most of these types of proceeding. They will be taken up in the order named.

(1) CIVIL SUITS AGAINST OFFICERS AS PRIVATE INDIVIDUALS.—No records of cases in which a plant quarantine officer has been sued personally for damages resulting from acts committed in his official capacity have been found, but closely similar cases have been before the courts involving rodent control, tax collection, and live stock sanitation. In one California case (Wolfsen v. Wheeler et al., 3rd Appel. Dist. Cal. Civ. Case 4691; Mar. 21, 1933), a civil suit recently resulted in judgment being secured against a county agricultural commissioner as an individual and against the deputy commissioner for the death of certain sheep said to be due to the "negligent spreading of poison in a field on which the plaintiff had a lease for pasturing sheep." The poison concerned was thallium and it was being used in order to control prairie dogs. The district court of appeals confirmed the judgment on March 21, 1933, saying:

"We think the facts disclosed by the record show not merely an error of judgment but a negligent use of a highly destructive poison where common prudence required a high degree of care, a care commensurate with the known virulence of thallium poison, which care the records show was not used."

Under two classical court decisions (Miller v. Horton, 152 Mass. 540; Pearson v. Zehr 138 Ill. 48) rendered in 1891 in Massachusetts and Illinois, respectively, the action of the State live stock sanitary boards in condemning horses for glanders and killing them was reviewed in local courts and decisions reached that the animals in question were not infected with the disease named. The supreme court in each of these two cases upheld the decision of the local court in issuing judgment against the enforcing officers for the value of the animals concerned, on the ground that the statute authorized the killing of only infected horses and that since these horses were not infected, in the opinion of the judge and jury, the live stock sanitary board did not have jurisdiction.

Nevertheless an administrative officer is not completely at the mercy of the civil courts when errors in judgment are committed in exercising the functions of his office, for the courts have upheld the "rule that the head of an executive department of the United States Government cannot be held in damages for acts done by him in relation to matters committed by law to his control or supervision." In Standard Nut Margarine Co. of Florida v. Mellon et al., the U. S. Supreme Court on October 22, 1934 (55 S. Ct. Rep. 124) upheld a decision of the United States Court of Appeals of the District of Columbia [72 F (2d) 557] under which the Commissioner of Internal Revenue and the Secretary and Acting Secretary of the Treasury were held "not personally liable in damages" even though their construction and application of the statute was "erroneous," in view of the fact that the subject matter was "within [the Commissioner's] jurisdiction and authority." Similarly in Brown v. Rudolph et al. [25F (2d) 540] the Court of Appeals of the District of Columbia ruled that when the District Commissioners "were exercising a discretion with which they were vested by law * * even though they had made a mistake, [they] would not have been liable to respond in damages."

(2) PROCEEDINGS INSTITUTED BY OFFICERS TO ENFORCE THEIR ADMINISTRATIVE ORDERS.—From time to time it becomes necessary for a plant quarantine official to secure the aid of a sheriff, constable, or other peace officer, in connection with the destruction of infested, infected, or dangerous material. Many State entomologists and apiary inspectors have had this experience. For example, Texas, under a State quarantine order enforces a fruit-free period during the spring and summer in the Lower Rio Grande valley as one of the measures to suppress the Mexican fruit fly. In March 1933, several of the residents of Willacy County refused to remove certain off-bloom ripening citrus fruit from their trees on the ground that they were not interested in the sale of fruit the following season and thus needed no permits for its shipment. After persuasive methods had failed, the State Commissioner of Agriculture prepared a condemnation order covering the groves of two of the objectors, one of

whom had 29 boxes of fruit, and the other considerably less. These orders were served by the sheriff of the county, and a crew of laborers was hired and paid by the State to remove and destroy the fruit. The other growers when they heard of this determined action by the State, allowed their fruit to be removed without further remonstrance. Cases of this kind are usually handled directly by the sheriff or constable without the necessity of a definite court order and no record has been found of a case in which such a court order was issued and the judge's decision later appealed to a higher court where it would become a matter of record.

Closely similar, however, are cases where the plant quarantine officers, instead of taking direct action to abate a nuisance, institute criminal prosecution against the owner for refusal to obey the order concerned. A well-known case of this kind was one tried in Arkansas (Howard v. State, 154 Ark. 430; 242 S. W. 818).

Howard was the defendant in the original action and was fined by the lower court. He appealed to the Supreme Court of Arkansas and in supporting the lower court and the action of the Arkansas State Plant Board, the State Supreme Court made a number of interesting and important decisions. These included findings (1) that the indictment was valid even though it charged the defendant with the violation of a rule adopted by the Arkansas State Plant Board rather than with a violation of the statute itself; (2) that judicial notice could be taken of the existence of the State Plant Board and its personnel even though the record of the case in the lower court was not complete on that point; (3) that the evidence of the chief inspector of that Board that he occupied that position was sufficient to justify the jury in so finding; (4) that the records of the minutes of the Board were sufficient to show that Rule 51 was adopted and that its publication in various papers was sufficient to show its promulgation; (5) that in authorizing the State Plant Board to make rules and regulations the legislature was not going beyond its authority and delegating its law-making powers, as the cedar rust regulation was not a law but a method adopted by the Board for carrying the law into effect; (6) that the rule itself was correct in not fixing a penalty, the latter being determined by the statute; (7) that the rule was a proper exercise of the State's police power, and that the State Plant Board in specifying the cutting of cedar trees rather than other methods for preventing or eradicating cedar rust was making an election between remedies which necessarily had to be left to the Board, and was not a question for the courts to determine.

In another Arkansas case (Jacobs v. State, 155 Ark. 95) decided December 2, 1922, the State Supreme Court ruled against the prosecution on the ground that the indictment was brought in the wrong county. T. L. Jacobs, of Benton County, sold trees to a mail order purchaser in Washington County. It was alleged that the trees were infected with crown gall, and Jacobs was indicted in Washington County for selling infected trees. The prosecution argued that the sale was not completed until the trees reached Washington County, since the buyer had retained the right to return the shipment if the stock should be found to

be infected. The Supreme Court held, however, that under the circumstances surrounding this case, the sale was completed when the trees were delivered to the common carrier in Benton County and that action should be instituted there. The State's case was accordingly dismissed.

Another feature of interest to plant quarantine officers was brought out in the Arkansas case just described, in the fact that the State Plant Board was not required to show any criminal intent on the part of the shipper. In this connection the supreme court cited People v. Roby (52 Mich. 577; 50 Am. Rep. 270), quoting as follows from the supreme court of Michigan: "Many statutes which are in the nature of police regulations, as this is, impose criminal penalties irrespective of any intent to violate them; the purpose being to require a degree of diligence for the protection of the public which will render violation impossible." Since it is probable that most violations of plant quarantines and other pest control orders take place either without criminal intent on the part of the violator or under conditions such that it is impossible to prove criminal intent, this court citation may often prove of value.

(3) EXTRAORDINARY WRITS, MANDAMUS, AND INJUNCTION.—The most common form of court attack which State plant quarantine officers must face consists of proceedings in which an individual seeks to enjoin the officer from enforcing certain orders. Most of the cases referred to in the author's previous paper (3) came before the court in that manner. Such cases are especially likely to result in the court's ruling on the broad, general principles of the matters before it, since the property owner is especially likely to base his case on constitutional provisions and court precedents.

Two cases of interest in this connection have been tried during the last five years in Georgia and Oklahoma, respectively. Neither of them reached a higher court, and accordingly have not been reported in journals that will be found in law libraries. They are noted here because of their interest to plant quarantine officers.

In the Georgia case (Head v. Yeomans et. al.) B. J. Head, operating as the American Plant Company, filed a mandamus petition in which he asked that the State Entomologist of Georgia be ordered to issue permits authorizing the plaintiff to sell sweet potato plants. The case came before Judge C. W. Worrill at Colquitt, Ga., on April 27, 1932. On the following day, the attorneys for the plaintiff and defendants having agreed, a consent order was issued under which the State Entomologist was directed to issue a permit to the defendant authorizing him to act "as a dealer to buy, sell, and deal in sweet potato plants according to the rules and regulations" of the State Entomologist, but "purchased, moved or shipped from sweet potato growers only, who are certified growers or dealers." and "that the individual plants of B. J. Head from potatoes on the Gordon farm or elsewhere which have not been certified shall not be moved, sold or given away unless and until they shall have been certified by the State Entomologist." While the consent order thus made provision for the plaintiff's continuing in business, it supported the State Entomologist's authority to control the conditions under which sweet potato plants could be certified for movement in Georgia.

The Oklahoma case referred to (Texhoma Ginning Co. v. Oklahoma State Plant Board, No. 62389) came before Judge Tomerlin at Oklahoma City on March 15, 1930. The plaintiff had filed a petition for mandamus to force the Oklahoma State Plant Board to authorize the shipment of some twenty cars of cottonseed from McKinney, Texas, into Oklahoma for planting purposes. The State Plant Board had refused the seed admittance into Oklahoma. The court decided that the action of the State Plant Board in refusing to admit the seed was authorized by law; and accordingly denied the writ of mandamus, and dismissed the case.

An injunction proceeding (Van Gunten v. Worthley, 159 N. E. 326) involving the laws of Ohio, was tried in 1927. The plaintiff had planted wheat on land which had been in corn the previous year and had not plowed up or destroyed the remnants of the corn crop. A general order had been issued under an Ohio statute, passed March 3, 1927 (112 Ohio Laws, p. 83, Sec. 5), requiring the destruction of remnants of the corn crop of 1926 throughout certain areas. The plaintiff petitioned that the defendant be enjoined from plowing up and interfering with the wheat crop. The court decided that the statute concerned was a constitutional and valid exercise of the police power and that "if the destruction of a small amount of a crop is reasonably necessary to prevent devastation of the whole of that crop, or of another, the State has full power to pursue the course that will conserve the food supply, so long as it acts reasonably."

The case of Wallace v. Dohner (165 N. E. 552) came before the higher court as an appeal from an injunction proceeding under which Dohner had attempted to enjoin the State Entomologist from enforcing an order which required all corn stalks in the European corn borer infested area of Indiana to be cut and burned or to be completely buried before May 1. The order had been issued under a State law authorizing the State Conservation Department to make rules and regulations for the prevention of plant diseases and pests. The court held that the legislation was "within the police power of the State, and **constitutional" and that "the rules and regulations embraced in the quarantine order were reasonable, and well within the authority delegated" to the Conservation Department by the statute.

(4) DIRECT APPEAL FROM AN ADMINISTRATIVE ORDER TO THE COURT UNDER PROCEDURE PRESCRIBED BY STATUTE.—Many administrative statutes, such as those authorizing State or city public service commissions to control the rates and nature of the service provided by public utilities, provide that persons or corporations affected adversely by an order of the commission may appeal directly to the court and that the court may review the case and determine whether the commission's orders were confiscatory, arbitrary, or unreasonable. Such provisions are not customary in plant quarantine statutes and accordingly aggrieved parties have ordinarily attacked pest control orders by means of injunction proceedings rather than direct appeal.

(5) COLLECTING THE EXPENSE OF EXECUTING PEST CONTROL ORDERS.—Plant quarantine statutes are usually so drafted as to state definitely whether the State is to assume the cost of carrying out pest control mea-

sures, and, if not, how they are to be collected from the property owners. For example, the laws of New York (Chapter 212, Section 164. 3, 1927) provide that in case the owner neglects or refuses to pay such costs into the State Treasury, "the amount thereof shall be recovered in a civil action to be brought and prosecuted by the attorney general in the name of the people of the State."

In some other sections of the country, it is more customary to enforce the collection of the costs as a tax against the property concerned, the cost being certified either through the Secretary of State or directly by the State Commissioner of Agriculture to the tax collecting officers of the county or municipality in which the property is located. While there have been hundreds of cases in which such expenses have been collected from property owners and paid into the treasury, either through taxation or voluntarily, such collection has seldom involved court record of the proceedings. However, the constitutionality of making the expense of abating nuisances of this type a lien upon the property concerned, was upheld by the supreme court of California in Los Angeles County v. Spencer (126 Calif. 670; 77 Am. St. Rep. 217; 59 Pac. 202). Other similar cases have also been decided in favor of the State (Balch v. Glen, 85 Kan. 735; Wedemyer v. Crouch, 122 Pac. 366).

What might be called the other side of the same picture occurs when it is necessary to destroy valuable infested or infected plants, or plants which constitute a public nuisance on account of being an alternate host of a plant disease. Plants such as red cedars, common barberry, or Ribes, may have a commercial value. State statutes usually, therefore, either definitely specify whether no damages shall be awarded for their destruction or in case the payment of damages is authorized, prescribe the methods by which the amounts shall be determined. As pointed out in previous papers (3, 5) statutes making no provision for the awarding of damages for the destruction of public nuisances have been upheld as not violating the 5th amendment to the U. S. Constitution. A clear statement of the legal principle upon which this is based is given in Conger, Receiver, v. Pierce County (18 A. L. R. 393 at 399). In discussing the damage claim involved in this case the court said that police power "has been defined as an inherent power in the State, which permits it to prevent all things harmful to the comfort, welfare, and safety of society. * * *Regulating and restricting the use of private property in the interest of the public is its chief business. It is the basis of the idea that the private individual must suffer without other compensation than the benefit to be received by the general public." (See also Mugler v. Kansas, 123 U. S. 623 at 669.)

PREPARATION FOR COURT ACTION.—Pest control administration in the nature of the case must be so constituted as to be able to deal with emergencies as they arise. Broad power has accordingly been given to plant quarantine officers to enable them to take such prompt action as may be required to bring insect or plant disease outbreaks under control. It is seldom necessary for a state entomologist to initiate court action except as he may have occasion from time to time to prosecute those refusing or neglecting to carry out the required measures.

When court cases arise, therefore, the plant quarantine officer is usually on the defensive, and he must be prepared either to defend himself personally in the case of a civil suit or to support his official responsibility in the case of an injunction or mandamus proceeding.

In being ready to defend himself, the plant quarantine officer should be prepared to show (1) that the statute concerned is a legitimate control measure adopted for public protection; (2) that the action he proposes to take or has taken under it is specifically authorized by the statute; (3) that he has complied with all legal requirements (such as hearings and notices) that the statutes prescribe; and (4) that the facts on which he is basing his action, including both the identity of the pest concerned and the adequacy and necessity of the control measures, are based on sound scientific evidence which can be supported by specialists in the particular field concerned. Several of these features are discussed in more detail by Becker (1) in 1926. Court decisions show that if the record is clear on these points, the enforcing officer has little to fear from court action.

Summary

(1) In rodent control and live stock sanitation cases, courts have held administrative officers personally liable in civil suit when private property has been damaged either through lack of care or through action not authorized by statute.

(2) When plant inspection officers have had to initiate court proceedings, such as in the case of criminal prosecution, they have been supported by higher courts when their action was authorized by statute and was scientifically sound. In one case at least it was held that the State was not required to show criminal intent. The same case was, however, lost because the defendant was indicted in a county different from the one in which he had his residence and from which he made the shipment concerned.

(3) In injunction and mandamus proceedings plant quarantine officers have been supported to the extent that they were able to show that their action was supported by statute and scientifically sound.

(4) Laws making the expense of abating a nuisance a lien upon the property concerned have been held constitutional.

(5) Compensation for the abatement of nuisances is not required by the Federal Constitution.

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RESTRICTED AREAS IN OTHERWISE HEALTHY NURSERIES

By W. W. ELLENWOOD, *Chief of the Division of Plant Industry, Ohio Department of Agriculture*

Administrators of laws, regulations and quarantine measures, which are designed for the purpose of suppressing plant diseases and insect pests in nursery stock, are constantly confronted with the problem of finding and utilizing the best possible means of adequately protecting the interest of the buying public and at the same time of keeping at a minimum the resultant material or financial loss to nurserymen. It seems fitting and proper that any useful means, employed in any state, in the accomplishment of the aims of administrators of Plant Pest laws should periodically be brought to the attention of those people in other states who have similar interests in order that some benefit may be derived from a mutual exchange of ideas on such matters. It is with this thought in mind that the writer has chosen to discuss briefly a plan adopted by the Division of Plant Industry of the Ohio Department of Agriculture which has to do with the restriction of certain nursery stock pertinent to the licensing of Ohio nurseries in 1934.

Usually, nursery certificates issued by any state attest to the fact that the nursery stock, in the particular nursery under consideration, "was found to be or was believed to be free from injurious insect pests or plant diseases" at the time of issuance of said certificate. No exceptions are noted on the face of the certificate in respect to any particular kind of stock which may have been growing on the nursery premises con, cerned at the time of inspection. In most states where, upon inspection-certain blocks of stock are found to be infested or infected with pests of importance the chief inspector has a choice of either issuing a certificate giving the nursery a clean bill of health; of with-holding license to operate until the pests involved have been brought under control, or of refusing to grant a certificate at all. Most laws on the subject fail to provide for any exceptions and practically no tolerance is allowed. Obviously, it is apparently unjust in most cases to refuse to grant or to withhold issuance of a certificate covering any and all stock in a given nursery just because a nurseryman may possess a certain kind or parcel of stock which may be objectionable from the standpoint of disease content. Especially is this true in case the disease condition involved is not amenable to control in a short period of time. It was to meet this situation that our method of restriction of stock was brought into use recently. The plan may not be new in some states. If it is not new to some inspectors very little time will be lost in review. If it is new, even to a few, some profit may be netted for pest suppression.

The aims to be accomplished through operation of the plan are threefold. First, it is hoped to eliminate or retard the dissemination of plant

pests by preventing the movement of any infested stock from restricted blocks. Second, to encourage nurserymen to clean up local pest outbreaks on their own premises in the shortest possible or reasonable time. And third, to permit nurserymen to continue to do business while their faulty stock is being destroyed or while it is undergoing the process of being placed in such condition that it will pass inspection.

During the process of examination of nursery stock, preliminary to certification for license, all blocks found to be objectionable on account of a diseased condition are placed under restriction. This means that such, and all, stock so restricted may not legally be sold or removed from the block until the restriction thus placed has been officially released by the Chief State Inspection Officer. This order of restraint may be compared in effect with a temporary injunction against disposal of the materials concerned. The placement of restriction is made formal and more effective through the employment of a written "Notice of Nursery Restriction" blank. On this blank the name and address of the nursery in question is stated. The section of law, from which authority is derived for the action, is cited. The location of the restricted stock is described. The kind of plants involved is named and the reason for the action is given. An order against removal of stock is made and this order is accompanied by a threat of revocation of Certificate of Inspection as a penalty for violation. Acceptance of the restriction is acknowledged by signature of the owner, or responsible officer of the nursery, and such acknowledgment is witnessed by a Deputy Inspector. Issuance of a certificate of nursery inspection is contingent on acceptance of the restriction notice. Sample restriction blanks may be had on application to the Division of Plant Industry, Ohio Department of Agriculture.

A check of restricted blocks may be made from time to time in order to determine whether proper measures have been taken to remedy the objectionable conditions and to obtain information on possible violation of the restriction.

Figuratively speaking, the proof of this pudding has been in the eating thereof. Apparently, the plan has effectively retarded or greatly discouraged the shipment of nursery stock which was found to be undesirable on account of disease content. It has induced a desire, and a realization of necessity on the part of nurserymen, to clean up their plantings and to keep them clean. A premium has thus been placed on clean stock. Many dollars were expended during the past summer in efforts to attain desired results. At present there exists a conspicuous tendency on the part of nurserymen to increase disease prevention activities which have in some cases become more or less dormant or latent during recent years which have been characterized generally by declining values of stock with consequent diminishing allotment of capital for the application of adequate sanitary measures. On the whole it seems safe to predict that Ohio nurserymen will do much more in the way of application of dormant sprays before the coming spring than has been attempted during any recent winter. The restriction weapon seems to have been responsible in part for this situation. Apparently the method used approaches fulfillment of the need.

NATIONAL PLANT BOARD

Report for 1934

By W. C. O'KANE, *Chairman*

In 1934 the chief activity of the National Plant Board has been to further correlation of state and Federal quarantine and control procedures and activities.

The chairman of the Board in company with L. A. Strong and A. S. Hoyt conferred with R. G. Tugwell, Under Secretary of Agriculture, concerning a proposal transmitted by representatives of the Southern Plant Board. Briefly, the proposal would provide for a comprehensive study of all domestic quarantines, such study to be arranged by the United States Department of Agriculture and to become, presumably, the basis for recommendations as to a more logical setting-up of quarantine structures. Subsequently, it was learned that the Department would probably be unwilling to undertake the extensive study suggested.

Following this a further conference was held with Department officials, looking toward the possibility of calling a general meeting of all state and Federal quarantine officers, at which the question of better correlation of quarantine and control activities might be fully discussed and perhaps some plan arrived at that would insure greater uniformity in such matters as inspection procedures, requirements for identification, and the like.

The proposal that such conference be held has specifically been endorsed by the Southern Plant Board, the Western Plant Board and the Eastern Plant Board.

Specific recommendations have come to the National Plant Board from regional boards and have received such action as was possible. These recommendations have been concerned with (1) further efforts toward possible cooperation on the part of the Department of Agriculture and the Post Office Department, to control mail shipments offered in violation of state quarantines; (2) efforts in control or eradication of the potato wart disease; (3) increased efforts in the direction of weed control.

In the course of the year the Chairman of the National Board had the privilege of meeting with each of the four regional boards. Early in the coming year the National Plant Board will hold a regular meeting at the same time and place as the Southern Plant Board. At later opportunities it is hoped that the National Board can have the pleasure and profit of following a similar plan with reference to other regional boards.

REPORT OF THE EASTERN PLANT BOARD

By E. N. CORY, *College Park, Md.*

The Eastern Plant Board held its annual meeting in New York on the 21st of November. This meeting was well attended by representatives of all but three of the states in the area. Owing to the splendid cooperation of Federal officials having charge of the various quarantine and control programs, a comprehensive picture of all such activities was obtained by those present at the meeting. This was supplemented by addresses and discussions of several research workers and state officials.

Two resolutions were passed, as follows:

WHEREAS, The Dutch Elm Disease threatens the existence of the elm trees of the Eastern United States, and extermination and control measures have been attempted and probably will be continued,

BE IT RESOLVED, That the Bureau of Entomology and Plant Quarantine be requested to give careful consideration to the advisability of placing restrictions on the movement of elm trees from the infected states or portions thereof to points outside.

WHEREAS, A conference of all State and Federal quarantine officers may be called to consider feasible ways of bringing about more uniformity in standards and methods of nursery inspection, including a possible plan for use of Federal tags on interstate shipments, such tags to be attached by State officers under appropriate definition of standards,

BE IT RESOLVED, That in the event of the calling of such a conference the Eastern Plant Board will ask its members to attend and to consider fairly any workable plan that the conference may devise or agree upon.

REPORT OF THE CENTRAL PLANT BOARD

By P. T. ULMAN, *Indianapolis, Ind.*

The Central Plant Board met in its 10th annual meeting at Lafayette, Indiana, on February 28th, 1934, the day preceding the annual meeting of the Central States Entomologists.

The 11th annual meeting will be held at Urbana, Illinois the first week of March, 1935 in connection with the Central States Entomologists and an invitation is extended to all state regulatory officials to attend this meeting.

Professor Geo. Dean of Kansas made the report of the National Plant Board and gave in some detail the discussion of the Board on Quarantine No. 37 and the recommendation that this quarantine be strengthened. This met with the approval of the Central Plant Board and the report was unanimously adopted.

Mr. L. H. Worthley of the Bureau of Plant Quarantine discussed the Japanese beetle situation during the past year. Mr. Worthley stated that 52,000 traps were distributed and operated outside of the infested area and 724 beetles were caught in 87 localities in these traps. Trapping activities in the Central States were confined to Ohio and Michigan, 2,150 traps being operated in Michigan and 7,500 traps were operated in Ohio.

The report on successful control of the beetle in the isolated infestations with arsenate of lead applications to the soil was of special interest.

Mr. P. A. Glenn reported on the phony peach situation in Illinois, stating that in 1933 thirteen peach trees had been found and destroyed. The experience with phony peach in Illinois indicates that the disease spreads slowly but persistently, and this coincides with the findings in other states.

Illinois is following the Federal Bureau's recommendation in regard to nursery stock by inspecting the environs of nurseries growing peach stock within a radius of one mile and by supervising the cutting out of the borer infested peach trees in nurseries within a radius of a mile from which any phony trees have existed during the growing season.

Mr. Ruggles of Minnesota, Mr. Chambers of Wisconsin, and Mr. Wallace of Indiana, all spoke on the lack of uniformity of regulations governing the movement of nursery stock between states.

Mr. Ruggles divided the states into eight groups, as follows:—

1. The following states charge fees to other states wishing to ship nursery stock into them:—

Alabama	$10.00	Arkansas	$ 1.00	S. Dakota	$1.00	Georgia	$ 5.00
Iowa	8.00	Virginia	10.00	Kentucky	5.00	Missouri	5.00
W. Virginia	20.00	Montana	25.00	New Mexico	5.00	Texas	5.00
Oklahoma	5.00	Oregon	20.00	Washington	5.00	Wyoming	10.00
Idaho	10.00	(if one or more out-of-state agents are employed)					

2. The following states force out-of-state nurseries to furnish bond in order to ship nursery stock into them:—

Georgia	$1,000.00	Montana	$1,000.00	Oklahoma	$1,000.00
Utah	500.00	Wyoming	500.00	Michigan	?
Idaho	5,000.00	(if one or more agents are employed)			

3. The following states force out-of-state nurseries to secure *special permit tags* from them to be attached to nursery stock to be shipped into these states:—

Alabama	Louisiana	Texas	Arkansas	Mississippi
Virginia	S. Carolina	New Mexico	W. Virginia	Florida
N. Carolina	Georgia	Oklahoma	Wyoming	

4. The following states require a special permit to be obtained from them before an out-of-state nursery can ship nursery stock into them:—

Alabama	Texas	Nebraska	Oklahoma	Arkansas
Wisconsin	New Mexico	Oregon	Connecticut	Kentucky
Virginia	Georgia	Louisiana	W. Virginia	S. Dakota
Indiana	Missouri	N. Carolina	Iowa	Montana
Ohio	Wyoming			

5. The following states force the filing of a special invoice previous to each shipment from out-of-state nurseries:—

Arkansas	Mississippi	Texas	Georgia	Montana
Utah	Louisiana	S. Carolina	Washington	

6. The following states require fumigation of nursery stock before it is admitted. (Fumigation is not a dependable procedure for such shipments as is borne out by the recent abolishment of fumigation requirements by the Dominion of Canada and many states.)

Florida	Mississippi	S. Carolina	Georgia	N. Carolina	Tennessee

7. *Nevada* requires that all shipments be inspected at the time of shipping.

8. *Missouri* requires that out-of-state nurseries in order to ship nursery stock into that state must sign a statement that the particular stock was grown on its own premises.

Mr. Chambers spoke on the reciprocal license law now operating in Wisconsin and discussed at length the need for greater uniformity in the state requirements on allowing nursery stock to enter a state.

A general discussion of the subject followed the talks and the opinion expressed was to the effect that the duty of the regulatory officials was to prevent the spread of diseases and insects and not to place prohibitive fees and requirements on nurserymen who are growing nursery stock in some other state.

The members were not in favor of resorting to retaliatory measures until other means of bringing about a uniform set of state requirements had been exhausted.

The following resolution was adopted:—

"Resolved that the practice of some states charging fees for out-of-state nurseries be discontinued and the original certification be accepted in all states."

Dr. O'Kane presented to the meeting a proposed plan for the use of a federal tag on all interstate shipments, the inspection work to be done by the respective state officials.

Quoting from Dr. O'Kane's talk.—

"The plan would be to gradually and carefully extend this manner of certifying interstate shipments, until eventually, if the idea works out well, materials moving interstate would move under a federal certificate, but the certifying officers would be the state organizations. Materials moving interstate would, of course, move under a state certificate and naturally this would be attached by the state service."

This proposal did not meet with the approval of the members present as they felt it would tend to complicate rather than simplify the present situation. No action was taken at the meeting due to the fact that part of the member states were not present. The secretary was instructed to secure the vote by mail after the minutes of the meeting had been sent out and the vote was as follows:

10 states voted NO
1 state undecided
1 state YES, but will abide by decision of other states
1 state not voting

The following officers were elected:

P. A. Glenn, Urbana, Illinois—President
P. T. Ulman, Indianapolis, Indiana—Sec'y.-Treasurer
Geo. A. Dean, Manhattan, Kansas—National Plant Board 2 yrs.
E. L. Chambers, Madison, Wisc.—National Plant Board 3 yrs.

REPORT OF THE WESTERN PLANT QUARANTINE BOARD

By A. C. FLEURY, *Sacramento, Cal.*

The Sixteenth Annual Conference of the Western Plant Quarantine Board was held at Salem, Oregon, June 19 to 21, 1934. Mr. Max Gehlhar, Director of Agriculture of the State of Oregon, and Mr. Charles A. Cole, Chief of the Division of Plant Industry, acted as hosts and did everything possible to make this meeting a success.

Some excellent papers were read on subjects of interest to Board members. These comprised "The White Pine Blister Rust Situation" by S. N. Wyckoff of the Office of Blister Rust Control, U. S. Department of Agriculture; "The Present Status of the European Earwig" by R. E. Dimick and Don C. Mote of the Oregon State College; "Treating Balled Nursery Stock to Destroy Earwig" by D. B. Mackie of the California Department of Agriculture; "Weed Investigations in California" by W. W. Robbins, Botanist with the California Agricultural Experiment Station; "Recent Observations of Strawberry Diseases" by Dr. S. M. Zeller, Plant Pathologist with the Oregon Agricultural Experiment Station; "Making Holly Safe for Shipment" by Don C. Mote and James R. Roaf of the Oregon State College and J. S. Wieman of the Department of Agriculture of Oregon; "Observations on Life Habits of *Cnephasia longana*" by W. D. Edwards, Kenneth Gray and Don C. Mote of the Oregon State College; "The Alfalfa Weevil—its Economic Importance Over-estimated" by W. H. Wicks of the Idaho Department of Agriculture and "The Fruit Fly Situation in Mexico" by E. Coppel Rivas of the Department of Agriculture of Mexico.

We were particularly honored at this conference by having in attendance Professor W. C. O'Kane, Chairman of the National Plant Board, and Dr. J. H. Montgomery of the State Plant Board of Florida, both of whom discussed National Plant Board problems with particular reference to securing greater uniformity in the various aspects of the field of duty that falls to inspection and quarantine officials. We were also honored to have present and address us Mr. N. B. Wentzel, Superintendent of the Division of Classification of the Post Office Department, Washington, D. C., who discussed plant quarantine and its relation to the Post Office Department. Dr. Leonard S. McLaine of the Department of Agriculture at Ottawa, Canada, was also present and discussed before the conference changes in insect and pest legislation in Canada.

Interesting reports were made by the quarantine officials of the various member States, British Columbia and Mexico on quarantine developments and pest control conditions in the areas under their jurisdiction.

Time was given for a complete and informal discussion on all of the papers read and subjects covered on the program.

The various Standing Committees reported as follows:

(1) WEED CONTROL COMMITTEE. This Committee recommended

(a) That each member state prepare a list of weed species considered as noxious and submit same to other member states.

(b) That each state endeavor to secure legislation that will permit condemnation and destruction of noxious weed seed wherever found, authorizing destruction of field seeds containing noxious weed seed, and prohibit growers or property owners from reseeding or planting seeds containing noxious weed seeds.

(c) That member states pass uniform noxious weed seed legislation.

(2) APIARY COMMITTEE. This Committee recommended

(a) A continuance of intensive apiary inspection in all member states and urged that apiaries found infected with bee diseases be placed under strict quarantine regulation until satisfactory abatement and cleanup work had been performed.

(b) That all certificates covering interstate movement of bees, apiary supplies and apiary products be based upon the most recent inspections that can conveniently be made by the state apiary inspectors.

(3) PUBLIC RELATIONS COMMITTEE. This Committee recommended that transportation agencies should be requested to advise the Secretary of the

proper officials of each such company to receive and disseminate quarantine data, following receipt of which the mailing list of the member states be corrected accordingly to insure the changes made in quarantines are promptly brought to the attention of transportation agents affected. This committee also recommended that each new quarantine or revision or amendment be briefed, such brief to be attached to the copy of such new quarantine revision or amendment when sent to transportation companies.

(4) POTATO TUBER MOTH COMMITTEE. This Committee recommended that due to insufficient available facts further investigation of the tuber moth situation in California by the potato industry and state officials of Idaho and Utah be made and if found satisfactory, these states were to amend their potato tuber moth quarantines to accept field and crop certification.

Resolutions were passed as follows:

(1) GENERAL RESOLUTIONS.

(a) Thanking the Oregon officials for their efforts in making our Salem meeting a success.

(b) Expressing appreciation to the Postmaster General for taking an active part in our discussion and deliberations through his representative, Mr. N. B. Wentzel.

(c) Expressing appreciation to Professor O'Kane of New Hampshire and Dr. Montgomery of Florida, Dr. Leonard S. McLaine of Canada, S. N. Wyckoff of the U. S. Department of Agriculture and to the staff of the Oregon State College for the very excellent papers and discussions.

(2) RECOGNITION OF STATE QUARANTINES BY THE POST OFFICE DEPARTMENT.

A resolution was again passed stressing the desirability of federal action by the Post Office Department and the Department of Agriculture whereby some method might be devised to bring about recognition of state plant quarantine regulations on the part of the Post Office Department.

(3) POTATO WART DISEASE.

A resolution was unanimously passed respectfully requesting the Secretary of Agriculture to immediately inaugurate eradication measures against all known infections of the potato wart disease in the United States, such eradication measures to be continued until the disease is eliminated and further, to extend the present federal potato wart quarantine embargo to all foreign countries in which that disease occurs.

(4) EXPRESSING APPRECIATION TO BUREAU OF PLANT QUARANTINE FOR PINK BOLLWORM ERADICATION ACTIVITIES.

A resolution was unanimously passed expressing sincere appreciation to the Bureau of Plant Quarantine, U. S. Department of Agriculture, for the excellence of the work performed in the eradication of the pink bollworm in the Salt River Valley in Arizona and approving and commending all efforts put forth to prevent dissemination and establishment of menacing insect pests and plant diseases within the confines of the agricultural areas of our commonwealth.

(5) APPROVING CONFERENCE OF QUARANTINE OFFICIALS OF ALL STATES TO CONSIDER PROPOSED ADOPTION OF FEDERAL TAG FOR INTERSTATE NURSERY SHIPMENTS.

A resolution was unanimously passed to the effect that the Western Plant Quarantine Board recognizes the necessity for attendance and participation by our member states in a conference, if and when called by the U. S. Department of Agriculture or by the National Plant Board, for the purpose of considering a proposal intended to develop a plan contemplating closer relationship as between federal and state organizations having jurisdiction over plant and plant product movement.

Mr. Charles A. Cole, Chief of the Division of Plant Industry, Department of Agriculture of the State of Oregon, was elected Chairman for the ensuing year; Mr.

Earl Hutchings, Agricultural Inspector of the State Board of Agriculture of Utah, was elected Vice-Chairman; and A. C. Fleury, Chief of the Bureau of Plant Quarantine of the California Department of Agriculture, was re-elected Secretary-Treasurer and was likewise elected to succeed himself as a delegate of the Western Plant Quarantine Board to the National Plant Board.

CHAIRMAN HOYT: The report of the committee on nominations is called for.

MR. WALLACE: The committee nominates S. B. Fracker for chairman and E. L. Chambers for secretary.

It was moved and seconded that nominations cease and that the committee nominees be declared elected. Carried.

Adjournment.

Scientific Notes

New Host Records for Two Mealybug Parasites. *Acerophagus pallidus* Timb., a minute yellow chalcid, was reared in small numbers from a large quantity of Mexican mealybug, *Phenococcus gosspyii* Town. and Ckll., collected by the writer in San Diego County in the fall of 1934. The only previously recorded host was *Pseudococcus eriogoni* Ehr. Apparently it attacks only immature mealy bugs.

Pseudaphycus angelicus How., a somewhat larger gray chalcid, was reared by C. J. Joubert from Mexican mealybug collected in central California. Recorded hosts are *Pseudococcus adonidum* L., *P. ryani* (Coq.), and *P. maritimus* Ehr. This apparently attacks mature females as well as the immature ones.

Both species are readily reared in confinement in the insectary.

STANLEY E. FLANDERS, *University of California Citrus Experiment Station, Riverside, California*

The Olive Scale, *Parlatoria oleae* Colv. This species of scale not known before to occur in California was recently found on olives near Fresno. Infested branches and fruit were received from this district the latter part of October, 1934. Upon investigation it was found that about seventeen acres of orchard were rather heavily infested. The infestation was uniform over the whole area, attacking the smaller branches, leaves, and fruit. The scales were so abundant that the fruit of the 1934 crop was completely ruined for canning purposes.

The olive trees were planted eighteen or twenty years ago but the scales only became noticeably abundant about 1931 and since that time have steadily become more and more injurious.

A single application of a three per cent commercial oil emulsion spray did not give effective control.

A thorough survey to determine the exact distribution of this pest has not been made and when this is done it is probable that it may be found to occur in other orchards in the Fresno district. Its identity may easily be confused by the grower with that of the ivy scale which is a very common pest of olives in the San Joaquin Valley.

F. H. WYMORE, *University of California, Davis, California*

Section of Apiculture

The meeting of the Apicultural Section convened at 7:30 P. M. in the Cardinal Room of the William Penn Hotel. In the absence of Dr. Brittain, the chairman, Mr. James I. Hambleton, was elected to preside. Papers presented for discussion are appended herewith.

Officers elected for the ensuing year were Geo. H. Rea, Chairman; W. A. Price, Secretary.

STUDIES IN BEE ACTIVITY DURING APPLE BLOOM

By W. H. Brittain

Great interest has been exhibited during the past few years in the subject of orchard pollination, as evidenced by the mass of literature that has been produced on the subject. Most apple producing States of the U. S. have published bulletins dealing with this question, and some work has also been done in Canada. Aside from the botanical and horticultural aspects of the problem, which, for obvious reasons, have been given most attention in the past, few quantitative data with respect to the comparative importance of various insect pollinators are available, and it is only fair to say that until recently our views were based mainly on observational studies, though the work of Fox Wilson (8, 9 and 10) and of Hooper (5 and 6) are deserving of special mention. The following discussion supplements the result of other studies reported elsewhere (1, 2 and 3).

Methods of Bee Counting.—During the past five years (7) an attempt has been made to evaluate the activities of hive and wild bees as orchard pollinators. This work has been based on definite counts made during the blossoming period of the apple, using 50 blossom clusters as the unit of observation and a period of ten minutes as the unit of time. Orchard observations have been supplemented, in the case of the hive bee by a study of the flight activities from the hive using a trapping method, a photoelectric device as described elsewhere (1) and, still more recently, by a photographic method described by Patterson (7), which gives a permanent record on a film of exits and entrances recorded as breaks in a solid line. It was found that positive film could be used satisfactorily for the purpose, which made the method considerably cheaper than it would have been had negative film been necessary.

None of the methods described in the foregoing are entirely satisfactory for obtaining accurate records of bee activity. All interfere more or less with the normal functioning of the hive. The record from the trapping method is not continuous. Where both the other methods are used, it is necessary to use a hive that is not too strong, in order to avoid clustering due to the interference with ventilation which this method entails. Hence, these methods are not suitable for securing records of activity from colonies of different strengths.

An additional disadvantage, in the case of the photographic method, is the large amount of heat produced by the two large bulbs which, being quite close to the front of the hive, raise its temperature to some extent even if properly insulated. The apparatus required for this method is fairly inexpensive though the cost of operation is rather high. Also a great deal of time is consumed in counting the exposed film, more, in fact, than in making the original exposure. On the other hand, it shows an advantage in that the record, once made, is permanent and can be checked at any time. Also, it is possible to secure a complete record from the hive with one instrument, and if desired, entrances as well as exits may be recorded on the same film.

The chief disadvantage of any of the electrical methods of counting lies in the cost. Each unit will record from only one tunnel, so that in order to record the total exists it would be necessary to have at least ten units, less than ten tunnels interfering with flight to too great an extent. As each photoelectric unit costs in the vicinity of one hundred dollars the expense is excessive.

The great advantage of the electrical counters is that the record is copied directly from the counter at the end of each time interval, and the counter set back to zero. Thus there is no time consumer in counting afterward, and possibility of error is reduced to a minimum.

A further method attempted, employed a spring switch to operate the counter. It is believed that with some refinement this method could be made practicable, but there has not been time to test it extensively. A counter of this type can be constructed at the rate of from twenty-five to thirty dollars.

In concluding this part of our paper, it may be said that the trapping method has proved most satisfactory for comparing the relative activity of hives of different types or strengths. Both the photoelectric and the photographic method give a continuous record of flight throughout the day and enable the investigator to compare the activity so recorded with the prevailing meteorological conditions. All, however, are open to certain objections and the somewhat crude method of unit counts remains the best that we have for studying the actual activity in bloom. In addition, this affords the only practical way of estimating the actual population available for pollinating any particular plant species, since all others measure only general activity. Unless the plant species studied greatly predominate over all the other sources of pasturage, this may well lead to misleading results if not checked by actual blossom counts. Moreover, with a sufficient number of counters available and trained in the work, there is good reason to believe that this method gives a reasonably accurate picture of the situation.

Species Involved

It has already been shown (1) that the chief role in apple pollination, aside from the hive bee, is played by certain species of the genera *Halictus* and *Andrena*, insects of other groups playing a comparatively minor role in the majority of locations studied. Large collections made at various points in the Annapolis Valley, Nova Scotia, showed *Halictus*

viridatus Lov. to be by far the most common, persistent and useful of the wild insect pollinators. *Andrena carlini* Ckll. probably came next in importance, with *A. wilkella* Kirby abundant in certain locations, particularly in the neighborhood of dyke lands. *A. arcuatus* and *H. cressoni* were found to be numerous only in certain restricted localities.

At Macdonald College, Quebec, on the Island of Montreal, *H. viridatus* was comparatively unimportant and no particular species took its place as the predominant form, though several species of *Andrena* were abundant, particularly *Andrena vicina* Sm., followed by *Andrena annae* Ckll., *Andrena flavoclypeata* Sm., (*bipunctata* Sm.), *A. forbesii* Robt., *A. crataegi* Robt., *A. miranda* Sm. and others. Collections made at Franklin Centre, Que., in 1934 gave quite a different picture. Again, however, *Halicti* were unimportant, though specimens of *H. viridatus* Lov., *H. pilosus* Sm., *H. lineatulus* Cufd. *H. macoupinensis* Robt. and a few others were obtained. The most numerous species taken was *Andrena flavoclypeata*, while the second largest proved to be *Colletes inaequalis* Say representing a genus previously unrecorded in our collections from apple bloom. No numerical rating of the relative abundance of the different species would be possible without much more extensive data.

The list of *Andrenidae* taken in apple bloom at the different localities studied is presented.

TABLE 1. LIST OF APPLE POLLINATORS AT DIFFERENT OBSERVATION STATIONS

King's Co., Nova Scotia	Macdonald College, Que.	Franklin Centre, Que.
Andrena bradleyi Vier.	*Andrena annae* Ckll.	*Andrena crataegi* Robt.
" *carlini* Ckll.	" *carlini* Ckll.	" *flavoclypeata* Cres.
" *crataegi* Robt.	" *crataegi* Robt.	" *miranda* Sm.
" *mariae* var. *concolor* Robt.	" *flavoclypeata* Sm.	" *regularis* Mall.
" *milwaukeensis* Graen.	" *forbesii* Robt.	" sp. *near frigida* Am.
" *miranda* Sm.	" *mariae* var.	
" *rugosa* Robt.	" *concolor* Robt.	*Colletes inaequalis* Say
" *thaspii* Graen.	" *miranda* Sm.	
" *vicina* Sm.	" *nasoni* Sm.	*Halictus arcuatus* Robt.
" *wilkella* Kby.	" *lata* Vier.	" *foxii* Robt.
	" *persimulata* Vier.	" *lineatusus* Cufd.
Halictus arcuatus Robt.	" *regularis* Mall.	" *macoupinensis* Robt.
" *coriaceus* Sm.	" *vicina* Sm.	" *pilosus* Sm.
" *cressonii* Robt.	" *wilkella* Kby.	" *viridatus* Lov.
" *foxii* Robt.		
" *leucozonius* (Schrank)	*Halictus macoupinensis* Robt.	
" *pectoralis* Sm.	" *provancheri* D. T.	
" *pilosus* Sm.	" *sparsus* Robt.	
" *provancheri* D. T.	" *viridatus* Lov.	
" *rubicundus* (Christ.)	" *zonulus* Sm.	
" *viridatus* Lov.		
" *zonulus* Sm.		

POPULATION STUDIES.—It should be noted that only population studies carried out over a long period of years in any given locality would be adequate to determine the exact status of the pollinating fauna. So far such studies have not been made, but records for a number or years are available from Nova Scotia and less extensive data for a single season (1933) from Macdonald College and from Franklin Centre, Que., (1934). The nature of the territory and other factors involved have been given elsewhere (1, 2 and 3) for the first two locations.

Franklin Centre differs from the other sites described, mainly in having an even larger proportion of waste or uncultivated land, in-

cluding abundant sites for the nesting of wild bees. The small proportion of orchard to uncultivated land, the very light bloom in the particular season in which our studies were made, taken together with the scarcity of other bee pasturage, presents quite a different picture from that afforded by the other sites.

In Nova Scotia it was noted that, during the period studied, the active pollinating population of wild bees, as indicated by the methods employed, was on the average about equal to the force that would be provided by placing one strong colony of hive bees per acre over the same territory. There were, of course, great variations between different sites and evidence of a recession in numbers during the season of 1932, followed by a marked abundance in 1933. However, weather conditions in a given season condition the number taken in the bloom to such an extent, that accurate estimates of the true population are impossible to make on the basis of this method. Without presenting the actual figures, however, it can be said that in the other centres studied the pollinating population during apple bloom was at least as great as in Nova Scotia, while at Franklin Centre the counts made during favourable conditions were considerably above the average.

Former studies (1) conducted with a view to determining the minimum concentration of hive bees necessary for orchard pollination, emphasized the fact that the entire district, and not the particular orchard involved, should be considered the unit. For example, the colonies placed at the rate of one to the acre in a ten acre orchard, situated in an acre that was practically solid orchard, gave a blossom count far smaller than the same number in an isolated orchard of the same size. In order to get approximately the same count in the former case, experiments indicate that it would have been necessary to use more than double the number of colonies.

In view of the foregoing tentative conclusions an effort was made to apply similar methods of study to a consideration of conditions at Macdonald College, Que. in 1933. Here twelve overwintered colonies were placed near a thirty acre orchard with no others within effective range, though perennial borders and flowering shrubs furnished a profusion of other bloom.

With only a single observer available for the blossoming period and only a single season's observations for study, it is impossible to make accurate comparisons between the two territories, and a detailed tabulation of the results would serve no useful purpose. However, there are a few points that seem worthy of mention. Records taken in the early part of the bloom yielded a count of solitary bees approximately the same as for hive bees during their period of maximum activity. In the early morning and late afternoon, however, hive bees were both actually and proportionately more numerous. With the coming into bloom of the later varieties and the simultaneous appearance of a wide variety of blossoms of various flowering shrubs, the number of visits of wild bees fell off both actually and proportionally due, no doubt, to the greater amount of pasturage available. Good counts of hive bees, however, were made throughout the entire bloom, a larger average number

having been recorded for the blossoming period than at any of our observation stations in Nova Scotia under similar conditions, in spite of the fact that only twelve colonies were present for thirty acres of orchard as compared with fifty in some of the Nova Scotia observation stations. This difference is apparently due to the difference in the amount of bloom available in the districts concerned, for, while other flowering species were numerous on the campus of Macdonald College, it is doubtful if the aggregate of such bloom would equal the pasturage furnished by an acre of apple orchard. Bearing in mind the fact that recommendations for the placing of hive bees for pollination purposes are usually expressed as a certain number per acre, the necessity of taking into consideration the total acreage available within range of effective flight and the concentration of other colonies in the district is further emphasized.

With regard to solitary bees, while the average number taken throughout the bloom was found to be equal to that of the average Annapolis Valley orchards, the discrepancy between the number recorded early in the bloom and that noted during the period of maximum bloom is noteworthy.

With very meagre records available from Franklin Centre, it is even more difficult to give an accurate picture of conditions existing there. Counts of hive bees in the bloom would, if made in an area of solid orchard in full bloom have indicated a considerable population, but only two hives could be found within the radius of a mile. Bees were taken in measurable numbers in the bloom three quarters of a mile from the colonies, whereas in an instance already reported (1) where ten colonies placed in a district of practically solid orchard, it was difficult to secure measurable numbers even one quarter of a mile from the colonies. In this district the counts of wild bees were over five times as great as the hive bees, amounting to over five per count on the average, which, even taking into account the conditions prevailing in this territory, still represents a considerable population, quite adequate for purposes of pollination, especially as the numbers persisted remarkably well throughout the bloom.

Bee Activity in Relation to Climatic Factors.—Earlier investigations have clearly brought out the fact that no single climatic factor can be considered apart from others. Nevertheless, it appears to be true that after a certain threshold temperature is reached, light conditions have a more profound influence on flight than temperature. Studies of the influence of light over short periods (1) have already been published, and figures showing the number of bees taken at different temperatures over a period of six years are now available. Details are shown in the figure 80. The curve for wild bees is more regular because of more even distribution, the number of colonies of hive bees near the different observation points varying greatly. In these curves the *apparent* optimum for hive bees is 67°F. and for wild bees 68°F., but this is not necessarily the case. The optimum temperature conditions do not coincide with the optimum light conditions, and the latter have a greater influence. Under normal conditions optimum temperature con-

FIG. 80.—Record of bee activity during bloom, with record of temperature and numbers of observations.

ditions occur later in the day than optimum light conditions and morning counts regularly give higher numbers than afternoon counts for a given temperature, because of the higher light values existing in the morning hours. Light values especially the significant ultra-violet fade out rapidly in the afternoon, though the temperature may be stationary or even rising, and the bee counts gradually recede with them. This offers a reasonable explanation of why the apparent peak for temperature activity is lower than would otherwise be the case. It is of interest to compare this figure with a curve showing the activity of bees throughout the day (1, p. 118) which shows the numbers of both hive and wild bees culminating at noon, though the temperature continues to rise for a time and then falls off slowly, whereas the bee count begins to fall off from the noon period onwards.

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THE EFFECT OF CERTAIN BACTERICIDES, ESPECIALLY COPPER SULPHATE, ON THE LONGEVITY OF HONEYBEES

By E. M. HILDEBRAND and E. F. PHILLIPS, *Cornell University, Ithaca, New York*

The proposal to apply certain bactericides to the open blossoms of the pome fruits in an attempt to prevent infection by the fire blight organism, *Erwinia amylovora*, should take into consideration the effect of such materials on honeybees. Since honeybees and other insects visit these blossoms and bring about pollination, the questions arise (1) whether such applications will be injurious to these insects, and also (2) whether such applications may affect the pollination of the blossoms. To get an answer to the first of these questions, honeybees have been

given sugar solutions containing some of the suggested bactericides, using the approximate strengths which have been employed, and with or without other foods, to determine if possible whether the bactericides used are injurious to the bees or whether they act as repellents. The results here reported have increased significance when considered in connection with other observations on fire blight control to be reported elsewhere by Hildebrand. A preliminary report by MacDaniels, Hildebrand and Burrell has already appeared bearing on the second question. (Am. Soc. Hort. Sc., XXX; pp. 26–31, 1933.)

The tests here reported, although planned to approximate in some degree the conditions in the orchard, were much more severe on the insects than orchard conditions for several reasons. The bactericide that would reach the exposed nectary of the pear flower would be an approximation of its original concentration only at the moment of application because of dilution from nectar secretion. In the case of the flowers of apple and quince, with protected nectaries, only a small proportion of the material on the exposed exterior would ordinarily reach the nectary. Other factors that further complicate the problem in the orchard are the relative numbers of flowers open at any one time and the fact that pollen may be contaminated.

Honeybees were placed in triangular wood and wire cloth cages 7/8" x 7 x 10, of a type used successfully in earlier experiments. These cages enabled the bees to feed readily from feeders placed above the cages and facilitated the determination of the death rates. Bees which died were removed daily and the average length of life of each lot was determined, the usual statistical methods being employed. The number of bees in each cage was not determined in advance, for that would unnecessarily disturb them. The number indicated for each feeding test was learned by removing the bees as they died. Six separate series of tests were run, each series being planned somewhat in relation to findings in the earlier tests. The number of bees varied from 198 to 661 in the different cages.

These tests were conducted in a room built as a constant temperature room but not accurately controlled. The temperatures differed somewhat during the progress of the several series, varying between 17 and 22° C. The room was kept dark except during the daily periods when dead bees were removed from the cages and the food supply replenished, lasting usually not more than ten minutes for each cage. There was some variation that was not controllable in the age and vigor of the bees used, in the amount of honey in their honey stomachs at the start of the tests and in other factors, so that in making comparisons of length of life on sugar solution alone with that on sugar solution containing a bactericide, care must be exercised to compare only tests within an individual series. The bees of each series were well mixed and approximately one cupful was added to each cage. They were for each series as uniform as it was possible to obtain them, in age, vigor and other variables. Tests I to XVI were run concurrently, with two starvation checks, I and IX, a few days apart. The accompanying tables give the material given the bees as food, the average length of life with the probable error, the number of bees used in each test, the total food ingested (not corrected for

evaporation), and the average amount of food ingested per bee per day. The term "bee days" used in the tables is defined as the sum of the numbers of bees alive each day during the test, and is virtually equivalent to the average length of life times the number of bees in the test.

In determining the strength of the bactericidal solution to be given the bees, attention was paid to conditions that might be anticipated in the orchard. For example, bordeaux mixture 1–3–50, containing one pound of copper sulphate and three pounds of hydrated lime to 50 gallons of water, makes a solution of approximately one part of copper sulphate and three parts of hydrated lime to 400 parts of water. The checks used were bees given a solution of sugar syrup and those given water only (causing starvation except for the food in the honey stomachs at the beginning of the test). After the bactericide had been dissolved in sterile distilled water, cane sugar was added in the proportion of one part of sugar to two parts of water by weight, giving the approximate density of a heavy nectar. The kinds of bactericides and the concentrations used are indicated for each test in the tables. In all these tests no visible chemical changes occurred in the materials fed, except that when cane sugar was added to bordeaux mixture and copper-lime dust solutions, copper sulphate was reduced, causing turbidity. Since sucrose is not a reducing sugar, this presumably means that in some manner these ingredients first caused hydrolysis of the sucrose. No effort was made to explain this phenomenon, but it was noted that the solutions in which reduction of the copper sulphate occurred were more toxic to bees than the same concentration of copper sulphate alone.

During the course of these experiments, it was noted that evaporation of the food solutions caused an apparent increase in consumption per bee per day, which was especially noticeable toward the end of each test. To make some correction for this error, in certain instances calculations have been made on the basis of conditions as they existed during that period when at least one-third of the bees under test were still alive, these results being given in separate columns. It was assumed in these calculations that the amount of food ingested per bee per day was accurate, so far as solids in the food were concerned, and that evaporation merely caused a greater concentration of the food ingested. Since the density of the sugar solutions used was relatively low, it is assumed that the amount of solid material was fairly accurate in proportion to the loss of weight of the original solution indicated each day. In the last series of tests, feeders were used which had a bakelite cap in which three small holes (1/32″) were drilled, which resulted in a material decrease in loss of weight due to evaporation. It has been learned from these tests that care should be exercised in the choice of feeding vials and other equipment. The weight losses in the earlier series must, therefore, not be taken as fully accurate but should be used only as a basis for comparison of the tests within each series. There was some loss from evaporation in the last series when the bakelite caps were used, so that even in this series the loss of weight does not accurately measure the food ingested.

The daily determination of the amount of food ingested showed that there is a tendency for the bees to ingest relatively large amounts on the

	Number	Fed	Average length of life	Prob. error	Number	Bee days	Food taken g.	Food per bee per day avg. g.	Condition while ⅔ of bees were alive: No. days	Bee days	Food taken	Food per bee per day	$CuSO_4$ per bee per day	$CuSO_4$ per day x A
Series 1	I	Water	4.5984	0.03018	493	2267	18.138	0.00800						
	II	$CuSO_4$ 6–50	3.1402	0.05816	271	851	7.333	0.00862						
	III	Cu_2O_3 5–50	4.0175	0.1400	228	916	20.220	0.02207						
	IV	Lime 6–50	7.8247	0.19265	251	1964	18.527	0.00944						
	V	B. M. 6–6–50	2.2240	0.03385	317	705	4.832	0.00685						
	VI	Z–L 6–6–50	17.6190	0.1917	483	8510	117.634	0.01382						
	VII	Cu–L. Dust 6–50	2.1955	0.06723	266	584	4.427	0.00758						
	VIII	Sugar	13.7721	0.1855	316	4352	123.205	0.02831						
Series 2	IX	Water	2.4820	0.02105	529	1313	16.824	0.01281						
	X	$CuSO_4$ 4–50	1.7938	0.00987	451	809	10.879	0.01345	3	768	8.960	0.01167		
	XI	$CuSO_4$ 2–50	2.5104	0.05303	529	1328	13.319	0.01003	3	1085	9.059	0.00835		
	XII	$CuSO_4$ 1–50	2.5364	0.04890	453	1149	13.306	0.01158	3	962	10.583	0.01100		
	XIII	$CuSO_4$ 0.5–50	3.8801	0.07070	292	1133	14.384	0.01269	4	958	10.040	0.01048		
	XIV	$CuSO_4$ 0.25–50	8.9659	0.22290	528	4734	46.352	0.00979	9	3215	33.846	0.01053		
	XV	B. M. 1–3–50	6.3843	0.13440	523	3339	71.441	0.02140						
	XVI	B. M. 3–6–50	3.3465	0.03810	482	1613	9.823	0.00609						
Series 3	XVII	Water	2.7257	0.0298	350	954	10.717	0.01123						
	XVIII	$CuSO_4$ 1–50	3.2753	0.0465	661	2165	23.898	0.01104	4	1903	20.776	0.01092		
	XIX	$CuSO_4$ 0.5–50	4.2734	0.0735	629	2688	33.811	0.01258	5	2240	26.655	0.01190		
	XX	$CuSO_4$ 0.25–50	6.6991	0.1443	555	3718	59.438	0.01599	7	288	45.016	0.01592		
	XXI	$CuSO_4$ 0.125–50	6.7831	0.1222	569	3859	111.910	0.02900	8	3223	96.766	0.03002		
	XXII	$CuSO_4$ 0.0625–50	11.4893	0.1871	560	6434	170.239	0.02646	13	5334	149.338	0.02800		
	XXIII	B. M. 1–3–50	3.1385	0.0574	498	1563	21.705	0.01389						
	XXIV	B. M. 0.5–1.5–50	5.7897	0.1629	466	2678	37.094	0.01385						
	XXV	Sugar	10.7411	0.1733	537	5728	162.293	0.02833						

	XXVI	Water	3.5183	0.0385	409	1439	12.459	0.00866					
	XXVII	Sucrose as in XI	5.0000	0.0994	545								
	XXVIII	$CuSO_4$ 0.0625–50	17.4987	0.1642	403	7052	251.528	0.03567					
Series 4	XXIX	Sugar Choice	15.9030	0.1277	402	6393	296.537	0.04638					
	XXX	$CuSO_4$ 1–50 and Sucrose	7.4375	0.2286	352								
	XXXI	Choice $CuSO_4$ 1–50 and Water	2.6588	0.0325	384								
	XXXII	Water	2.1637	0.0054	227	490	11.273	0.02301	2	429	6.682	0.01558	
	XXXIII	Sugar	17.5890	0.2709	236	4139	162.528	0.03927	20	3789	152.700	0.04030	
	XXXIV	$CuSO_4$ 1–50	4.3888	0.1161	252	1097	20.533	0.01872	5	919	12.554	0.01366	0.0000468	0.0002054
	XXXV	$CuSO_4$ 0.5–50	7.5520	0.2579	221	1669	32.240	0.01932	9	1287	21.975	0.01707	0.0000242	0.0001628
	XXXVI	$CuSO_4$ 0.25–50	12.7020	0.3056	245	3152	64.801	0.02056	16	2717	56.316	0.02073	0.0000129	0.0000711
Series 5	XXXVII	$CuSO_4$ 0.125–50	16.6042	0.2741	235	3902	105.378	0.02701	19	3532	94.658	0.02680	0.0000084	0.0001395
	XXXVIII	$CuSO_4$ 0.0625–50	16.8045	0.2445	220	3697	149.181	0.04035	19	3421	136.853	0.04000	0.0000063	0.0001059
	XXXIX	Lime 3–50	13.2611	0.2222	226	3003	54.564	0.01817	16	2839	50.702	0.01786		
	XL	B. M. 1–3–50	3.0580	0.0472	293	896	13.809	0.01541	4	853	12.155	0.01425		
	XLI	Zinc Lime 3–3–50	13.0303	0.2649	198	2580	31.418	0.01257	10	2368	27.575	0.01164		
	XLII	Powd. B. M. 1–100	2.1034	0.0403	290	610	6.936	0.01137	3	577	5.823	0.01009		
	XLIII	Water	2.8059	0.0299	335	1273								
	XLIV	Sugar	9.7207	0.1424	290	2818	36.884	0.01309	11	2647	35.258	0.01332		
	XLV	$CuSO_4$ 1–50	3.6027	0.0708	370	1703	9.953	0.00584	5	1493	7.499	0.00502	0.0000146	0.0000526
	XLVI	$CuSO_4$ 0.5–50	4.2088	0.0947	249	1300	10.526	0.00810	6	1155	9.050	0.00784	0.0000101	0.0000425
	XLVII	$CuSO_4$ 0.25–50	6.0673	0.1081	327	2311	19.919	0.00862	8	2050	18.527	0.00904	0.0000054	0.0000328
Series 6	XLVIII	$CuSO_4$ 0.125–50	8.6176	0.1554	272	2616	23.817	0.00910	12	2439	22.943	0.00941	0.0000028	0.0000241
	XLIX	$CuSO_4$ 0.0625–50	8.4743	0.1288	272	2577	25.647	0.00995	11	2409	23.942	0.00994	0.00000155	0.0000131
	L	Choice $CuSO_4$ 1–50 and Sugar	8.3992	0.1114	334	3133								
	LI	Choice $CuSO_4$ 0.25–50 and sugar	10.1994	0.1391	351	3930								
	LII	Alter { $CuSO_4$ 1–50 Sugar	4.0216	0.0606	416									

first day, with a decrease thereafter. On the supposition that this heavy ingestion might be due to excitement, in the last series all the bees were given only sugar solution for the first day, the food thereafter given bees in different cages being varied according to the tests to be made. While this seems to have tended somewhat to prolong life, no marked difference can be detected in the results of this series from the others.

For certain feedings in which copper sulphate was given, computations have been made of the amount of bactericide ingested per bee per day by dry weight of copper sulphate, and then this average is multiplied by the average length of life of the bees in the test. These data are useful in an attempt to determine whether the bees in the tests were getting more or less of the copper sulphate when it was given to them in more dilute form. From these data it is possible to determine whether the average minimum lethal dose can be determined from such tests.

DISCUSSION AND CONCLUSIONS.—From the data at hand, certain conclusions may be drawn, as follows:—

(1) The minimum lethal dose cannot be accurately determined from experiments of this kind, for the reason that bees can ingest more than the minimum lethal dose prior to the occurrence of death. The minimum lethal dose is obviously less than the amount ingested by the bees getting the amount which caused most rapid death.

(2) Since the stronger copper sulphate solutions caused a more rapid death rate than occurred with water alone, it is concluded that copper sulphate in such amounts is either poisonous to the bees, or that it disturbs their physiological processes, or that both things occur.

(3) Since the total amount of food ingested per bee per day was decreased when copper sulphate was added to the sugar solution, it is concluded that the bactericide acts as a repellent to bees.

(4) Since at the greater dilutions of copper sulphate, there was no significant shortening of life, it is concluded that such minute amounts are not poisonous, but it is to be noted that even with the most dilute solutions of this bactericide, the food ingested was always less than when sugar solution of the same strength was given alone. This indicates that even in the most dilute amounts, copper sulphate is a repellent. Lime alone did not shorten life but it decreased the consumption per bee per day. The zinc-lime mixture with sugar solution acted much as did lime.

(5) In test XXVII, bees to almost the identical number were given the same amounts of sugar as were consumed by bees in the feeding in test XI (copper sulphate 2–50). The bees of the second test obviously did not obtain an adequate amount of food to prolong their lives to a normal length, but they lived longer than did bees in test XI. While there may have been some difference in the age and vigor of the bees in these separate tests, the results suggest that the copper sulphate of this concentration was poisonous to bees.

(6) While copper sulphate is poisonous to bees, it is also a repellent, and from these tests it is therefore impossible to predict the damage to bees which might result from the application of copper sulphate, or the other bactericides, to open fruit blossoms. More casual observations in

orchards where these materials were applied as sprays or dusts failed to reveal an appreciable increase in the death rate of honeybees, but an experimental approach to this question is needed. The observations, however, are in line with the results of experiments by MacDaniels, et al (1934) where it was found that no appreciable reduction in fruit set occurred under good pollination conditions.

SOME EFFECTS OF RELATIVE HUMIDITY ON THE LENGTH OF LIFE AND FOOD CONSUMPTION OF HONEYBEES

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Although temperature and relative humidity are closely correlated, it would appear that each may influence metabolism independently. While the conditions of relative humidity are often given in reports of temperature effects on honeybees, little attention seems to have been given to the effect of relative humidity on the metabolic processes of bees. The only previous attempt to determine the effect of relative humidity on the metabolic rate of bees appears to be that of Wolfenbarger (1934) who reports that he was unable to obtain satisfactory relative humidity control by drawing air through sulfuric acid solutions in a closed system.

The present paper is a report of a preliminary experiment conducted during the winter of 1933–34. Well insulated cabinets (11.75 x 18.50 x 14.75 inches) served as constant relative humidity chambers, saturated salt solutions being used as the controlling agents. The salt solutions were placed in pans (9 x 14 x 2.5 inches) and wicks made of heavy Canton flannel were used to increase the surface of the solutions. The wicks were hung from the tops of the cabinets, the lower ends immersed in the solutions in the pans, and formed a curtain completely surrounding the sides of the space above the pans. In this way the surface of the controlling agent in each cabinet was increased to about 1400 square inches or more than eleven times the area provided by the solution in the pan alone. As a result, the ratio of salt solution surface to cubic inches of air in the cabinets was greater than 1 to 3. This allowed the provision of ventilation for the needs of the bees without interfering appreciably with the control of relative humidity.

The wicks were kept saturated and wet with the salt solutions by dipping them in the solutions in the pans once each day and some further control of the solution in the wicks was doubtless obtained through capillarity. It is probably true, however, that the control became someless effective near the end of each daily period than earlier as there was a tendency for the solutions on the cloth wicks to become slightly less than saturated in those chambers where the relative humidity was maintained below that of the room. In the chambers maintaining higher relative humidities than that of the room there was a tendency for the wicks to dry-out. This condition might have been avoided by making the cabinets more nearly air tight or by more frequent dipping of the wicks. Measurements of the relative humidities of the cabinets were made by means

of thermocouples as described in an earlier paper (Woodrow, 1934). Numerous observations, made at half-hourly intervals, indicated rapid regulation of relative humidity by the solutions. At the end of each day, observations were made of the relative humidity in each cabinet before it was opened for observing the bees and the dipping of the wick. These records indicate that the slight changes in concentration of the solutions on the wicks did not seriously affect the relative humidity of the air in the cabinets.

The bees used were confined in small wire cloth cages (0.75 x 3.25 x 6.25 inches) which were supported about two inches above the salt solutions in the pans. The bees were taken from a colony being wintered outdoors on November 26, 1933, approximately equal numbers being placed in each cage. A 6-dram vial, having an aluminum screw-cap perforated by about five small holes, was filled with 50 per cent sucrose solution and inverted over the wire cloth of each cage to provide food for the bees and the amount of food consumed each day was determined by weighing. In addition to the feeder containing sucrose solution, each cage of bees was given a similar feeder filled with distilled water but apparently this was unnecessary as only slight quantities were removed.

In this preliminary experiment it seemed desirable to study the effects of relative humidity at only a few points in the range of possible humidity conditions, the availability of suitable salts determining partly the points chosen. Potassium acetate, sodium bromide and sodium chloride were selected for this purpose and distilled water was used to provide the highest relative humidity. One cage of bees was exposed to room conditions during the experiment and served as a check, although the relative humidity of the room was not constant. The small, well insulated dark room used for the experiment provided like conditions for each cabinet and kept a comparatively even temperature and relative humidity.

Table 1 gives a summary of the results obtained in the experiment. While there is little difference in the average food consumption, with the exception of that of the bees at the highest relative humidity, the bees exposed to low relative humidity lived appreciably longer than those at higher relative humidities. The amount of food taken from the feeders was determined throughout the experiment but the food consumption recorded is calculated for the period from the beginning of the experiment until the date of the average length of life, as this method increases the accuracy of this figure. Although the evaporation from the feeders is slight, due to the small surface exposed at the holes in the feeders, this factor becomes increasingly important as the number of bees in the cages becomes smaller and the total quantity of food removed per day becomes less. The experimental error involved in the handling of the vials also is more nearly insignificant during the first part of the period for the same reason. During the first part of the period, owing to the greater number of bees in the cages and the resulting larger quantity of food removed from each feeder, the per cent of error introduced by these factors is slight.

TABLE 1. COMPARISON OF AVERAGE LENGTH OF LIFE AND THE AMOUNT OF 50 PER CENT SUCROSE SOLUTION CONSUMED BY BEES AT VARIOUS CONSTANT RELATIVE HUMIDITIES

Per cent relative humidity (average of all observations)	Control agent	No. of bees	Average length of life, days	Maximum length of life, days	Average food consumption (mg. per bee per day)
25.52	CH_3COOK	192	35.2292 ±0.6866	72	67.83
50.90	None	188	30.9894 ±0.5053	60	63.46
57.38	NaBr	204	30.7402 ±0.3832	56	62.69
73.50	NaCl	192	24.5885 ±0.3435	46	64.34
97.19	H_2O	193	8.4249 ±0.0945	16	38.51

Temperature of room (average of all observations) 70.21° F.

Figure 81 shows that the food consumption per bee becomes progressively less as the period of confinement continues. This seems to be due partly to the fact that the bees become accustomed to being confined and are more quiet but may also be due partly to their inability to feed, as is pointed out later.

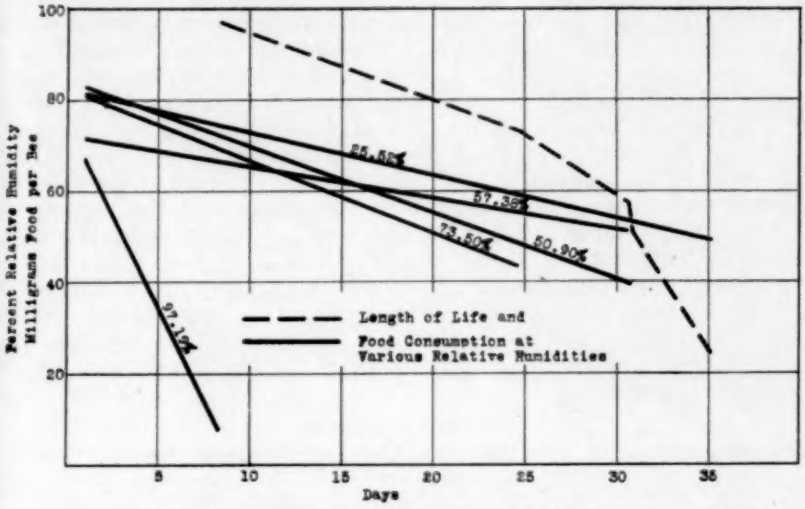

FIG. 81.—Average length of life and food consumption of bees exposed to various constant relative humidities.

During the first day of the experiment, no differences were observed between the bees in the different cabinets. At the end of the second day the bees at the highest relative humidity were slightly restless and some fecal matter was noticed on the tray beneath the cage. When sugar syrup is fed to bees confined in cages, they tend to keep themselves gorged and when no feces are present the abdomen remains transparent. As the experiment progressed, the abdomens of the bees at the higher relative humidities rapidly became opaque and the release of fecal material became progressively more general. Examination of the dead bees removed from these cages revealed that the abdomens were filled with a yellowish, watery substance, devoid of sugar. No further examination was made of this material. When the bees became filled with this watery

substance, they became sluggish and moved about in the cages only with difficulty.

The first evidence of feces accumulation at the lowest relative humidity was noticed about the twentieth day and this condition slowly became more pronounced as the experiment progressed. As the bees in the different cages became more sluggish due to fecal accumulations, it is probable that some of them actually starved to death. The progressively smaller food consumption per bee per day no doubt is due partly to the fact that some of the bees were unable to feed.

It appears that accumulation of feces is one cause of the death of the bees exposed to the higher ranges of relative humidity. It also appears that since the fecal material accumulated was largely water that the bees were unable to eliminate their metabolic water together with the water in which the food was dissolved when the relative humidity was too high to permit sufficient transpiration. It should be pointed out, however, that had the bees been fed on a more concentrated food, the accumulation of the water in which the food was dissolved would have been materially lessened and it is likely that the bees exposed to the higher relative humidities would not have been affected as quickly as was the case when a 50 per cent sugar solution was fed. With the exception of the bees at the highest relative humidity, there is little difference in the amount of food consumed by the bees at the different relative humidities. The smaller food consumption of the bees at the highest relative humidity may be due largely to their inability to feed and to the fact that the death rate was so high.

Although high relative humidities tend to shorten the length of life and low relative humidities to lengthen it when bees are fed a dilute food, this does not seem to be due to a difference in the metabolic rate but rather to a difference in the ability of the bees to eliminate water through transpiration.

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THE CAUSE OF DYSENTERY IN HONEYBEES[1]

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Dysentery, a winter disease of honeybees, has been known since Aristotle's time. Normal defecation in the honeybee takes place on the wing during the flight season. The wintering bee, confined to the hive, is deprived of this opportunity, and the fecal material accumulates in the rectum. An over-accumulation of feces may lead to a forcible discharge in the hive or on the alighting board; this occurrence is called dysentery.

[1]Published with the permission of the Director of the Wisconsin Agricultural Experiment Station.

The history of dysentery with a review of the most important literature on the subject is offered by Zander (4) and Weippl (3). The disease was formerly attributed to a variety of causes, such as—1. Unfit winter stores, 2. Sugars containing bluing or sugars other than sucrose, such as maltose, malt syrup, potato syrup, etc., 3. Quick crystallizing honeys, fall honeys, buckwheat-honey, honeydew, etc., 4. Fermented and spoiled honeys, 5. Eating of pollen by bees due to untimely broodrearing, 6. Moisture in the hive, 7. Moist site for apiary, or moisture in the bee cellar, 8. Apiary exposed to winds or drafty winter quarters, 9. Weak colonies, 10. Improper ventilation of hives or bee cellars, 11. Lack of water (Durstnot), 12. Queenless colonies, 13. An excess of winter stores, 14. Disturbance of the colonies, 15. Sudden excitement of the bees, 16. Severe cold temperatures, 17. Confinement of long duration, 18. Burned honey or burned sugar syrup stores.

An accumulation of indigestible constituents from dark honeys and honeydew, such as dextrin, melizitose, minerals, etc., in the rectum of the honeybees is often believed to cause dysentery.

In the course of many years, the writer visited many wintering apiaries, both out of doors and in bee cellars. It was observed that dysentery never seemed to depend on the physical environment of the wintering colonies. At any time of the fall, winter or early spring months it was found that the disease did or did not occur in moist, dry, drafty, cold or warm, winter quarters. It was concluded that the occurrence of the disease must primarily depend upon the quality of the winter stores, regardless of other environmental factors. For that reason, the composition of stored winter food in relation to dysentery was investigated.

Methods. For two successive winters the bees in the University of Wisconsin apiary were divided in groups of two. Each group was given natural stores during the winter or provided stores of a known composition. The procedure for the second winter was decided by the results of the first winter's experiments.

Colonies which were to winter on other than natural stores were shaken from their combs into hives containing only dry, white comb. They were fed a certain food combination by the pepper-box method until sufficient food was stored away and capped. The colonies were fed the latter part of September and early October. After a general flight these colonies were transferred to the bee cellar.

Other colonies, fed on candy and liquid syrup in the bee cellar, were transferred to white, dry, comb, free from any deposit, and then placed in the bee cellar. Here the colonies were fed through an oval opening in the inner cover. During the first winter the cellar temperature was 36° F. by thermostatic control, and remained fairly constant. During the second winter, the cellar temperature was raised to 42° F. to enable the colonies on a candy or syrup diet to obtain their food. Thirty-six degrees Fahrenheit was found to be too low and did not allow the consumption of food offered through the top of the hive. Cardboard pieces to cover the entire bottom board were inserted in each colony to collect the dead bees and the hive debris. The colonies were visited daily, and inspected with the least amount of disturbance to note abnormal be-

havior and dysentery outbreaks. A small flash light was used for this purpose, as excessive lighting causes a general disturbance in the bee cellar.

During the first winter several samples were taken from each colony. Each sample consisted of about 100 bees. They were taken when the first dysentery case occurred and just previous to the removal of the bees from winter quarters. Sampling took place three times during the second season. First, at the time of the initial occurrence of the disease, second, during midwinter and the third samples were taken at the end of the winter season.

The first winter the following stores were provided to the experimental groups: a) Original stores containing some honeydew, b) Original stores plus one 10-pound pail of 50/50 sugar syrup, c) Fall honey collected after August 10 (clover and goldenrod), d) 25/75 sugar syrup, e) 50/50 sugar syrup, f) 50/50 sugar syrup inoculated with Red Star Yeast. This syrup was fed to the bees after fermentation was well advanced, g) 25/75 sugar syrup which was allowed to boil for several hours until well browned, h) Same honey as group "a" except that the honey was autoclaved with 15 pounds pressure for 20 minutes, i) Sugar syrup containing 5% dextrin[2], j) Sugar syrup containing 10% dextrin, k) Sugar syrup containing 15% dextrin. During the second winter similar groups were prepared, l) Original stores containing a little honeydew, m) Original stores crystallized in refrigerator, n) Original stores from the previous year, o) 50/50 sugar syrup fed in greenhouse and partly crystallized in refrigerator, p) 50/50 sugar syrup fed in liquid form in the bee cellar, q) 25/75 sugar syrup fed in liquid form in bee cellar, r) Candy (honey and pulverized sugar containing 12% moisture) fed in bee cellar, s) Original stores from the previous year with additional water feeding, t) Candy containing honey, pulverized sugar, 7.3% pollen and 10% moisture.

During the first winter the last general flight took place on December 2. On December 10 the bees were removed to winter quarters. On January 4 the colonies of group "a" started spotting their cardboard and appeared restless; dysentery became apparent.

On January 10, group "h," January 20, group "b," and on February 4, group "c" showed dysentery, while the rest of the groups remained healthy throughout winter and spring.

To obtain sample bees from all parts of the clusters, the bees were removed with tweezers and killed in a cyanide jar. In the laboratory they were swiftly weighed or dissected. The dissections consisted either of the removal of the entire intestine or only the rectum. Each sample of 100 bees was divided in two groups of 50, each group was manipulated separately, and the mean of the two results calculated.

After weighing, the moisture contents of whole bees, as well as bees without heads and intestinal tracts, was determined. The dessication was performed by 48 hours of heating at 80° F. in a vacuum oven. In

[2]This dextrin was white dextrin from potatoes. To a 50/50 syrup solution enough dextrin was added to assume a dextrin content of 5, 10 and 15% respectively, after the bees lowered the moisture content of the fluid to approximately 20%.

TABLE 1

Expt. groups	Total weight of bees	H_2O in bees minus head and intestine %	Feces %	H_2O in feces %	Acidity of feces—NaOH per 10 gr. of feces mg.	N. in feces %	Total sugar in feces %	Dextrin in feces %	Ash in feces %	H_2O in available stores %	Degree of dysentery
Group d—25/75[1] syrup stored	0.0937	65.72	7.5	71.1	76.3	6.12	6.1	none	2.83	18.68	none
Group c—50/50[1] syrup stored	0.0877	65.97	8.3	67.7	48.4	5.08	3	none	2.54	18.04	none
Group f—50/50 fermented syrup stored	0.0867	65.48	9.2	77.8	14.7	6.55	2.4	1.5	1.61	19.33	none
Group g—25/75[1] browned syrup stored	0.0948	63.57	9.2	74.8	22.1	5.13	2	none	1.52	19.89	none
Group i—5% dextrin in syrup stored	0.0958	66.25	11.5	70.2	43.6	5.14	3.4	2.2	2.06	20.33	none
Group j—10% dextrin in syrup stored	0.1016	65.10	13.8	69.9	50.4	3.19	5.3	8.2	2.51	15	none
Group e—Fall honey	0.1228	66.48	33.9	85.8	6.9	4.89[3]	5.3	5.1	2.05	23.05	*
Group b—Original honey plus 10%[2] 50/50 syrup	0.1299	66.65	38.1	83.5	5.4	4.57[3]	3.7	2.4	3.56	22.87	**
Group h—Sterilized honey	0.1243	63.36	38.4	80.8	38.3	3.39[3]	7.9	2.5	1.02	22.69	***
Group a—Original stores	0.1383	67.65	39.4	86	6.1	5.18[3]	6.14	4.5	1.61	23.62	****

[1]50/50 syrup—half water, half cane sugar, by weight.
[2]25/75 syrup—¼ water, ¾ cane sugar, by weight.
[3]Stores contained pollen; other colonies devoid of pollen.
Acidity, Nitrogen, Sugars, Dextrin and Ash in feces are figured in per cent of the feces solids.
Degree of dysentery; * few spots on cardboard; ** cardboard fairly well spotted; *** cardboard and frontboard badly soiled; **** general defecation inside and outside the hive.

other tests the rectum of the bees was dissected, and the amount of accumulated feces was determined by the total body weight of the bees expressed in percentages.

The moisture content of feces was also determined by the above method. The dry matter of feces was analyzed for several constituents: a) Free acid, by titration with N/10 NaOH solution, b) Invert sugar and sucrose by Elser's (1) micro-method, c) By the same method the dextrin contents were determined, d) The nitrogen was determined by the Gunning-Arnold modification of the Kjeldahl method, e) And the ash content was determined by Elser's (1) method.

The results of the various tests at the end of the first winter are presented in Table 1. The colonies were arranged according to the amount of accumulated feces in proportion to the total body weight. Group "k" died of starvation before any tests could be performed; although it had 15% dextrin in its stores, no sign of dysentery was evident. The food presented to this group was of a consistency quite similar to the paste used by paperhangers. For this reason, the acceptance was extremely slow, and at the time of the first severe cold wave, each colony had consumed and stored little more than a gallon.

From the table it can be seen that dextrin, ash, sugar and nitrogenous accumulations in the feces cannot be related to the occurrence of dysentery. A slightly higher amount of undigested sugars was present in the diseased groups and also the healthy group "d" wintered on 25/75 sugar syrup. Nitrogenous material was found not only in the groups whose stores contained pollen but also in colonies devoid of pollen. If undigested pollen were responsible for the disease, a high percentage of nitrogenous material would be evident in the feces. The only factor showing any relation to the amount of accumulated feces was the moisture content. The dry matter in feces did not increase fast enough to be considered a causative factor of dysentery. The dilution of feces, however, is very conspicuous and increased as the season advanced and as dysentery became more apparent. The first bees left the cluster to discharge their feces around the entrance when the mean fecal accumulations amounted to 33% of the total body weight of the bees and when the feces contained approximately 80% moisture. A higher moisture content was also apparent in the body of the bees from such colonies after the head and the entire alimentary canal were removed. Since the interior of the hives was absolutely dry, the source of this over-abundant water remained unknown, until the colonies were removed from the bee cellar. After the first appearance of dysentery, it was noted that in the diseased colonies honey-crystals collected on the inserted cardboards, while in the healthy colonies only cappings and fecal pellets of waxmoth larvae were found. On April 1, the day the bees were placed outdoors, samples of their stores were obtained. It was found that the stores of the diseased colonies were completely granulated, while the stores of the healthy colonies were just beginning to granulate. In the process of granulation, part of the honey crystallizes and consequently contains only crystallization water. The liquid portion interspersed between the crystals becomes diluted. The wintering bee is not able to consume the crystals and must feed on the dilute portion.

An attempt was made to obtain the liquid portion of the granulated stores by means of a syringe, but a solution entirely free of crystals could not be drawn. Finally, the combs containing the winter stores of all groups were finely chopped up. A glass tube was filled with each sample and centrifuged for 1 hour at 2000 revolutions per minute. This produced a separation in three layers, the wax and comb material on top, the liquid portion in the middle, and the honey crystals at the bottom of the tube. After the waxy layer was removed the moisture content of the liquid portion was determined by the sand bath method in a vacuum oven. A lower number of centrifuge revolutions per minute, as well as a shorter time of operation, did not produce a complete separation. Due to the extended operation time, as well as the swift running of the separator, a heating of the glass tubes was unavoidable. This heating, of course, must have caused a partial dissolving of the honey crystals, and in turn, a lowering of the moisture content of the liquid portion. It may be safely concluded that the available liquid portion of granulated honey contains a higher amount of moisture than the moisture determined by the above procedure. The results of the moisture determinations appear in Table 1 and indicate a direct correlation between dysentery and the dilution of the available food.

Chilling or disturbing individual bees or entire colonies is often cited as a cause of dysentery. Tests however, have shown that both cause defecation if the rectum is fairly well filled, but do not produce dysentery in bees with small fecal accumulations. Chilling caused by cold rain upon colonies with a screened top, as experienced by Weippl (3), was also performed, and produced dysentery in June, within 36 hours. But apparently this was not due only to chilling. The bees try to keep dry by taking up the rain water. They cannot dispose of the excess water, since the rain prevents their flight. The water remains in the body, fills the rectum, and a watery discharge of feces within the hive takes place. The occurrence of dysentery is similar in protected colonies interrupted during the honey flow by rain. The bees are shut in and forced to eat unripe honey. Within a short time, the rectum expands and defecation may take place. The defecation in colonies suffering from a severe shock, disturbance of any kind—such as transportation, sudden queenlessness, etc., should not be classed as dysentery. The feces, usually discharged in little elongated pellets, is semi-solid and lacks the typical odor of dysentery feces. This type of defecation is comparable to a form of diarrhea, also occurring in higher animals caused by sudden fright or horror.

The second winter's experiments were confined to an investigation of the excess moisture in the available winter food. The experimental preparations are described above, and the same analytical procedures were engaged. To show the course of the disease, the data in Table 2 presents results of all three tests performed during the time of cellar confinement.

Group "t" colonies, fed with candy containing 7.3% pollen, died on March 15 without any signs of dysentery. They began rearing brood January 20 and gradually diminished in number. Remarkable is the

TABLE 2*

Expt. groups	Total body weight	Feces %	H_2O in feces %	Total body weight	Feces %	H_2O in feces %	Total body weight	Feces %	H_2O in feces %	Degree of dysentery	H_2O in available food
	Early Feb.—Test 1			Late Feb. Early March—Test 2			Late March—Test 3				
Group o—50/50 syrup crystallized in refrigerator	.0892	12.2	71.9	.1044	24.4	80.5	.1224	34.9	86.2	**	19.26
Group t—candy plus 7.3% pollen	.1060	16.6	78.4	.1269	17.1	79.7	——	died	——	none	10
Group r—candy	.1181	18.3	79.7	.1058	24	80.5	.1143	32.8	80.7	none	12
Group n—Original stores from previous year	.1057	29.2	72.9	.1261	36.4	78.8	.1269	41.3	80.7	*	19.22
Group p—50/50 syrup cellar feeding	.1212	32.4	82.6	.1212	40.6	82.7	.1331	44.2	83	**	not determined
Group s—original honey, previous year plus H_2O	.1371	34.0	82.6	.1256	48.6	83	.1320	44.5	81.6	***	24.55
Group l—original stores	.1245	34.9	80.6	.1506	38.7	85.8	.1487	44.9	86.1	***	23
Group m—original crystallized in refrigerator	.1232	36.8	84.5	.1287	42.2	86.2	.1433	43.0	87	****	22.6
Group q—25/75 syrup cellar feeding	.1058	38.8	84	.1143	39	84.7	.1143	41	84.5	****	not determined

*Last general flight on November 19. Removed to winter quarters on December 22. Placed outdoors again on April 1.

gain in weight from the first to the second weighing of these bees. This increase was due to restoration of their bodies, and not to fecal accumulations; this confirms Haydak's (2) findings in his pollen substitute experiments. The group fed on candy alone reached only the verge of a dysentery outbreak, although no spotting occurred. The condensation of vapors from the interior of the bee hive, as well as the air of the cellar, were unavoidable. These condensed on the candy lumps, and the bees consumed the moisture first, resulting in a dilution of their minimal fecal accumulations.

Dysentery occurred in all colonies except the ones fed candy. Important is the fact that granulated stores originated from 50/50 sugar syrup feeding will produce dysentery. Dysentery was believed to be due to a lack of water (Durstnot), and feeding of water was formerly recommended as a cure. But this procedure increased the degree of dysentery.

A crystallization of stores at the start of the season produced the disease more rapidly and to a higher degree. This can be observed by comparing group "l" with "m." Both groups were supplied the same stores, the only difference being that the stores of group "m" were granulated in a cold chamber before the hives were populated.

The two groups fed liquid syrup in the bee cellar suffered from dysentery, although theif food consisted of only pure cane sugar dissolved in distilled water. No indication of the moisture contents of the available food for these two groups could be calculated for Table 2 since the concentrations of the solutions actually absorbed remain unknown. Attempts to remove excess moisture from the food by suspending drops and fanning was observed in both groups. It seems, however, that bees are more successful in lowering the moisture contents of the 50/50 syrup, since the group fed on the 25/75 solution, suffered the most severe case of dysentery. Defecation of a large number of bees lowered the amount of feces or prevented the amount of feces reaching the expected peak in the late March tests. Defecation on a large scale takes place when the fecal accumulations reach about 45%. Again, the relation of excess moisture to the available food shows a distinct relation to the occurrence and the degree of dysentery.

After a general cleansing flight, the diseased colonies took up their broodrearing activities in a normal way. But they never reached full strength nor produced as large a honey crop as colonies which wintered normally.

Summary and Conclusions

1. Dysentery of honeybees is caused by excess moisture in the feces.
2. This excess moisture is due to the consumption of dilute food or water. It is generally produced by crystallization of the stores; this divides the honey or syrup into a solid crystalline portion and a liquid portion. The liquid portion contains an excess quantity of moisture.
3. Pollen, dextrin, minerals, burned sugar, and fermenting syrup do not produce dysentery.
4. Chilling and disturbing honeybees may cause defecation, but do not produce dysentery in a healthy colony.

5. Long confinement of bees during the winter as well as a short confinement on unripe honey, produces dysentery.
6. Water alone or dilute syrups produce dysentery in bees if absorbed during confinement.
7. Dysentery appears when the fecal accumulations reach 33% of the total body weight of the bees. General defecation does not take place until the accumulation reaches about 45%.

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OBSERVATIONS ON THE BIOLOGY OF THE GREATER WAX MOTH, *GALLERIA MELLONELLA* L.

By V. G. MILUM, and H. W. GEUTHER

Since various writers have recorded numerous observations on the life history of the greater wax moth, *Galleria mellonella* L., the authors of this paper wish to report only a few points not commonly given in the literature to add to or corrobate the observations of others.

The number of eggs laid by individual females varied from 400 to 839 in a group of 12 females, the average being 754 per individual. Eggs were deposited singly to as many as 127 in one group. The proportion of sexes in one group of 323 adults was 172 males to 151 females.

Unmated and separately confined females began to oviposit within 36 hours after emergence but the eggs never hatched although subjected to the same conditions as normal eggs which hatched.

To test the preference of the females for egg laying positions, a number of pieces of brood comb were suspended on the points of six-penny nails projecting through pieces of comb honey sections which were in turn laid on other pieces of section and fastened in place by glue at one end. The nail head prevented full contact of the two pieces of section at the opposite end. Several moths were released in the container and after 24 hours the combs and supports were examined for the presence of eggs. While the moths frequented the combs in great numbers, no eggs were found upon the pieces of brood comb except those laid in tiny crevices where the cocoons were pulled away from the waxen cell walls. On the other hand, the vast majority of the eggs deposited were found between the closely attached ends of the two sections and where the sections rested upon the underlying support thus indicating that the moths preferred to lay their eggs in cracks and crevices which barely admitted the ovipositor. In nature, this apparently serves as a means of protection for the eggs. It would also indicate that in the case of comb honey especially,

where moths have not had access to the hive parts, that it is important that the eggs around the edges of the hive body should be destroyed by some means, or the sections removed from the comb honey super or else follow ordinary fumigation methods to prevent damage to the combs.

Certain observations on the larval habits of *G. mellonella* under restricted food conditions lead us to suspect that the injury of the latter on comb honey is often incorrectly laid to the lesser wax moth, *Achroia grisella* Fabr. In fact, we have had various individuals indicate that the tunnelling in cappings of comb honey was that of the lesser wax moth but we believe in many cases, these larvae would prove to be the young of the greater wax moth if they were transferred to a diet of brood combs. We recently examined several dozen unfumigated tunnel-damaged sections of comb honey without finding a single living larvae and no adults within the containers. In support of our theory we offer the following information, the obtaining of which was stimulated by casual observations of two larvae approximately 3/8 inch in length, supplied by an Illinois beekeeper who found them tunnelling in comb honey. One of these larvae was placed on brood comb and developed into a full sized adult male greater wax moth. The other larva was placed on a section of comb honey, although it lived for several weeks, grew smaller and smaller, apparently, with each succeeding molt and eventually died, no doubt because of the lack of proper food elements in comb honey which are ordinarily in brood combs.

Other normal larvae taken from brood combs were placed upon comb honey as their sole diet. Only the larger larvae pupated and emerged as adults, while the smaller ones grew smaller and eventually died. Insufficient observations do not permit us to indicate whether such larvae, having reached a certain instar are able to continue their development but such seems to be the case.

On the other hand it is quite a common observation that when a certain group of moths are allowed to feed upon a limited supply of brood combs, the first one or more generations of adults will be of normal size, but as the supply of available food diminishes, the succeeding generations became smaller and smaller. The difference in size is, no doubt, due to the lack of sufficient food supply for growth of the larger individuals yet allowing for completion of the life cycle, the adults of which seem to be able to reproduce normally if a new food supply is given.

While the authors have not been able to secure any specimens of the lesser wax moth in Illinois, we have been assured by various individuals that it is actually here. Reports from California, Colorado, Ohio, Texas and other states would indicate that it might be rather generally distributed. We are indebted to Dr. Carl Heinrich of the U. S. Bureau of Entomology for the information that the U. S. National Museum has specimens of the lesser wax moth, *Achroia grisella* Fabr. from Washington, D. C.; Somerset, Berwyn and Plummer's Island in Maryland; Fairfax Co., Virginia; Chicopee and Amherst, Massachusetts, and Jefferson, Ohio, as well as several foreign countries.

Besides the greater wax moth, the authors have also found that in Illinois dry brood combs when stored at room temperatures may commonly

be infested with the larvae of the Indian meal moth, *Plodia interpunctella* Hubner, especially if a few dead bees are in the combs. However, we have found no serious damage as a result of such infestation.

STUDIES ON THE BACTERIA ASSOCIATED WITH PARAFOULBROOD

By C. E. BURNSIDE, *Assistant Apiculturist, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture,* and R. E. FOSTER, *Apiary Inspector, State Plant Board, Gainesville, Fla.*

In 1932 the names of parafoulbrood and *Bacillus para-alvei*, respectively, were suggested for a disease of brood of bees that appears different from the brood diseases previously described, and for the causative organism. (1) A few months later a brief description of this disease and its gross symptoms was published. (3) In the present paper the bacterial forms found in affected brood or obtained in culture are briefly described and illustrated. Tentative conclusions are presented regarding the etiology of parafoulbrood.

Parafoulbrood has been found only in limited sections of North Carolina, South Carolina, Georgia, and Florida. The disease affects principally larvae in open cells, but larvae and pupae in sealed cells are sometimes killed. The gross symptoms resemble those of European foulbrood, and it is sometimes difficult to distinguish in the apiary which of these diseases is present. Ropiness of decayed larvae often resembles closely the ropiness present in American foulbrood.

The bacterial forms in larvae affected by parafoulbrood also resemble the forms present in European foulbrood, which seems to indicate a close relationship between these two diseases. Parafoulbrood might readily be mistaken for European foulbrood upon microscopical examination, particularly before infection becomes advanced in a colony. Owing to extreme variability of the bacterial forms present in affected brood, it is not possible to state definitely what forms of bacteria will be found when an affected larva is examined.

THE BACTERIA FOUND IN AFFECTED BROOD.—In recently infected larvae the bacteria usually consist principally of small rods and coccoid and coccus-shaped cells with intergrading forms. (Fig. 82, A.) Either coccoid or coccus-shaped cells may occur in the same chain with rods, which seems to prove a common origin. Rods of medium average size may be present in small numbers.

During early infection the bacteria multiply rapidly. Coccoid cells usually increase most rapidly at first, but in some larvae, rod-shaped forms also increase rapidly. Pointed or lancet-shaped cells usually appear after infection is well advanced. This form seems to originate from the coccoid, coccus, and rod-shaped bacterial forms and may replace them more or less completely in advanced stages of disease. (Fig. 82, B.) At about the time larvae die, lancet-shaped cells usually predominate but their relative number may vary from about 99 per cent to so small a per-

centage that they are difficult to find in microscopic mounts. The fact that lancet-shaped cells are rarely seen dividing and do not appear until disease is well advanced seems to indicate that they represent a mature or dormant stage of other morphological forms. The medium-sized rods sometimes seen in infected larvae usually multiply slowly but may multiply rapidly and become very numerous in advanced stages of disease. Long, slender, faintly-staining rods may be present in small numbers during any stage of infection.

Dead larvae may decay more or less completely or dry down to light-colored scales with but slight decay. The principal putrefactive form is the sporogenic stage of *B. para-alvei* (Fig. 82, C), which appears to hold the same relationship to parafoulbrood that *B. alvei* holds to European foulbrood. (2) Coccoid bacteria are numerous in some decayed larvae.

THE BACTERIA OBTAINED IN CULTURES FROM AFFECTED BROOD.—Most cultures prepared from sick or dead brood yield *B. para-alvei* which sporulate promptly. Cultures prepared from contents of the digestive tract of recently infected larvae frequently yield a coccoid bacterium either in apparently pure culture or in combination with *B. para-alvei*. (Fig., 82 D.) These coccoid forms differ somewhat among different cultures but in general resemble closely *Streptococcus apis* Maassen. Occasionally no growth can be detected on agar slants inoculated with bacteria from sick larvae. Rapid and luxuriant growth has been obtained in every instance, however, when sterile filtrate prepared from macerated honeybee larvae was inoculated with bacteria from the same sick larvae that failed to give growth on nutrient agar. Cultures in filtrate usually yielded coccoid bacteria indistinguishable morphologically from bacteria present in recently infected larvae. After being cultured in brood filtrate, this coccoid form grew readily on yeast-extract egg-yolk agar and resembled the coccoid bacteria cultured directly from brood on this agar.

Bacillus para-alvei

The following description is of the sporogenic form of *B. para-alvei* as it usually appears in freshly isolated cultures. The species is capable of marked variation and modification and produces "variants", some of which were isolated and cultured.

OCCURRENCE.—In colonies affected by parafoulbrood.

MORPHOLOGY.—Vegetative cells rod-shaped and motile. They occur singly, in pairs, or in short chains. On bouillon agar they average about 3 μ by 0.7 μ, but average measurements vary, depending upon the medium and the physiological condition of the organism. Small extremes are common. Spores form in a subcentral position within the rods. They are oval and average about 1.7 μ long by slightly more than 1 μ thick. Much smaller spores are sometimes seen.

TEMPERATURE AND OXYGEN REQUIREMENTS.—The optimum is about 35° to 37° C., but good growth occurs over a fairly wide range of temperature. It grows best in presence of oxygen; multiplication and sporulation are retarded by anaerobic conditions.

AGAR SLANTS.—A smooth, grayish-white, translucent, glistening layer usually incorporated within the surface layer of the agar spreads rapidly over bouillon slants. On yeast-extract egg-yolk agar growth is more luxuriant than on bouillon agar; the layer is faintly buff-white and usually wrinkled.

POTATO SLANTS.—Growth smooth and grayish-white at first, becoming buff or brown in old cultures.

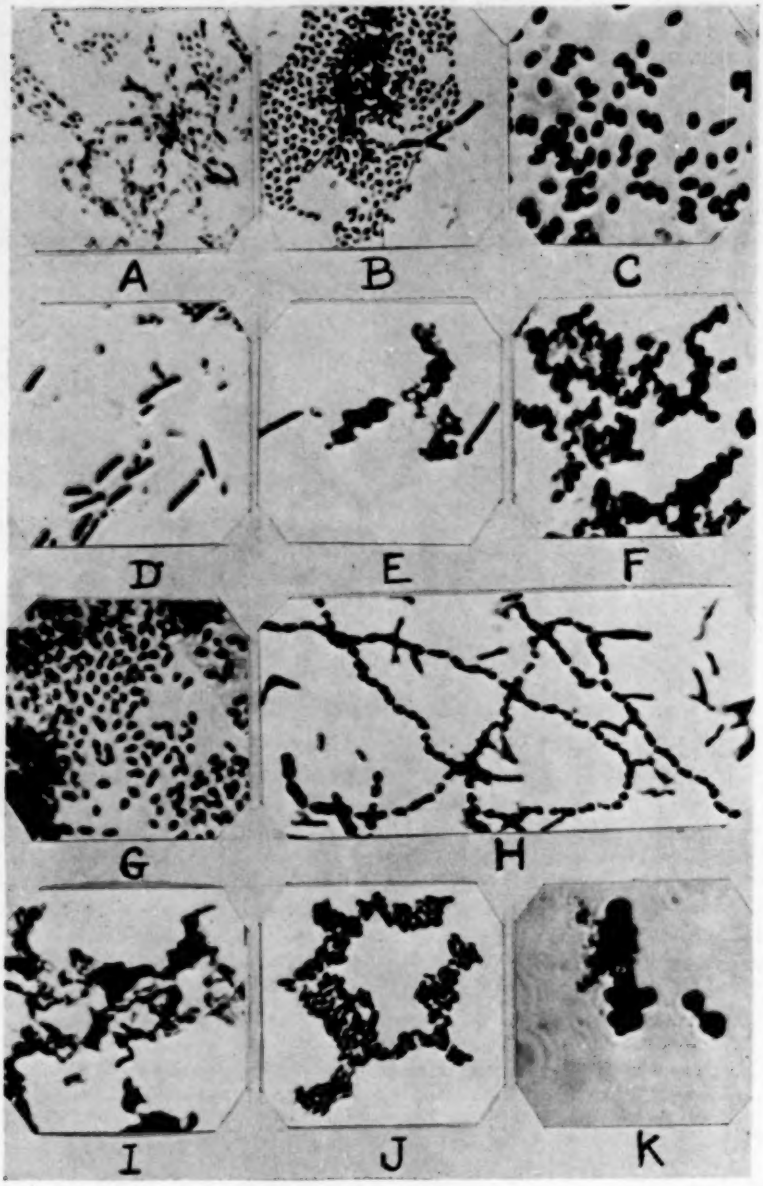

FIG. 82.—Bacterial forms associated with parafoulbrood and variants produced in culture; A, Coccus, coccoid, and rod-shaped forms from a recently infected larva; B, Lancet-shaped cells from a larva at about the time of death; C, Spores of *Bacillus para-alvei* from bouillon-agar culture; D, Rod-shaped and

AGAR PLATES.—Surface colonies circular and granular; submerged colonies oval or nearly globose; outline smooth at first, becoming partially or entirely irregularly fringed. Central portions of submerged colonies may be darker than margins.

LIQUID MEDIUM.—Bouillon broth clouded within 24 hours; the bacteria settling in old cultures; a grayish-white pellicle forming after about 5 days. Growth in potato broth is less luxuriant than in bouillon. Milk is slowly coagulated, acidity is increased, and litmus is discharged from litmus milk.

STAINING PROPERTIES.—Both rods and spores stain readily with the usual dyes.

SUGARS.—With the usual sugars, acid but no gas is produced.

Bacillus para-alvei was found only in diseased colonies. When agar slants were inoculated with a single loop full of honey or pollen from colonies badly infected with parafoulbrood, *B. para-alvei* was usually obtained in culture. Cultures from the digestive tract of apparently healthy larvae in colonies with advanced cases of parafoulbrood likewise yield *B. para-alvei* with considerable regularity. The writers have not found this bacillus in healthy colonies or in colonies affected by other brood diseases or disorders, although many thousand dead larvae have been examined microscopically and several thousand cultures prepared from them. It seems highly probable, however, that through robbing or transfer of equipment this bacillus may occasionally be present in colonies in which parafoulbrood never has been active. Requeening of infected colonies with Italian queens usually results in disappearance of active infection, but viable spores of *B. para-alvei* would likely remain for several years.

MIXED INFECTION WITH PARAFOULBROOD.—Parafoulbrood was found in mixed infection with other brood diseases in only a very few instances. Mixed infection of parafoulbrood with European foulbrood was found more frequently than with other brood diseases. This can probably be explained by the fact that the conditions which favor spread of these two diseases (black or hybrid bees, weak colonies, absence of honey flow) are similar. *B. alvei* and *B. para-alvei* were both found in about 5 per cent of the samples from apiaries or localities where both these diseases are prevalent.

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coccoid bacterial cells from the same agar culture prepared from the digestive tract of an infected larva. Occasionally pairs were seen which appeared to consist of a coccoid and a rod-shaped cell; E, Coccus and coccoid-shaped "variants" in a culture of sporogenic *B. para-alvei* in unheated filtrate prepared from honeybee larvae; F, A coccoid "variant" of *B. para-alvei* isolated from the culture represented by Fig. E. There was considerable variation in morphology among different bacterial cells of this form as well as in the method of division; G, Another coccoid "variant" isolated from the culture represented by Fig. E. In cultures on yeast-extract egg-yolk agar this variant produced many lancet-shaped cells indistinguishable morphologically from the lancet-shaped cells in diseased larvae; H, "Variants" of sporogenic *B. para-alvei* from a culture in filtrate prepared with honeybee larvae. The long chains consisted principally of coccoid-shaped cells but some chains consisted of a combination of coccus, coccoid, and rod-shaped cells; I, A small beaded rod-shaped variant of sporogenic *B. para-alvei* isolated from a culture in brood filtrate; J, Culture of the coccoid form isolated from a recently infected larva on bouillon agar containing 10 per cent honey. When honey was added to bouillon agar the percentage of lancet-shaped bacterial cells was increased; K, Culture of the coccoid isolated from an infected larva in bouillon to which both honey and egg yolk were added. In this medium the coccoid form either failed to grow or grew as giant coccoid cells.

EXPERIMENTAL INOCULATIONS WITH PARAFOULBROOD.—Colonies were inoculated with parafoulbrood at Thomasville, Ga., and combs of brood were inoculated and kept in an incubator at Somerset, Md. The disease was transmitted in every case when colonies of common black and hybrid bees were inoculated with bacteria from sick and dead brood. (3) Infection was not produced when two hybrid colonies were inoculated by spraying the brood combs with a heavy water suspension of *B. para-alvei* spores from old agar cultures. Another colony was inoculated by the same method with a water suspension of old larval scales in which spores of *B. para-alvei* were the only bacteria found by microscopical examination. One sick coiled larva attacked by coccoid bacteria and 11 extended larvae decayed by sporogenic *B. para-alvei* were found in the combs within a week. Neither coccoid nor lancet-shaped bacteria were found in microscopic mounts from any of the 11 decayed larvae. Infection disappeared promptly and no more dead brood was found.

In the following experiments the inoculum was sprayed over combs of brood which were kept in a moist chamber in an incubator at 34° C. With a water suspension of macerated larvae sick or dead of parafoulbrood, 10 per cent to 15 per cent of the larvae in each of 3 inoculated combs appear to be attacked and killed by bacteria, but the microscopic picture was not typical of parafoulbrood. Bacteria multiplied abundantly within the digestive tract of the infected larvae but lancet-shaped and coccoid bacteria in coherent masses such as usually occur in naturally infected larvae were not found in the artificially inoculated larvae. A water suspension prepared from the infected larvae described above was used to inoculate another comb of brood but the larvae in this comb were not infected. Several inoculations were also made with cultures of coccoid bacteria isolated from sick larvae but none of the inoculated larvae were attacked.

VARIABILITY AND PLEOMORPHISM IN BACILLUS PARA-ALVEI.—This bacillus shows marked variability and pleomorphism, depending to some extent on culture medium and temperature but perhaps in greater degree upon its physiological condition. Several variants or mutants have been observed in cultures and some of these have been isolated and cultured in an apparently stabilized condition.

In liquid medium, sporulation is retarded and in subsequent transfers retardation is increased. After about 10 generations in potato broth at room temperature the ability to form spores may be partially or entirely lost, at least temporarily. When the bacillus was plated from potato broth some of the cultures on bouillon agar or yeast-extract egg-yolk agar sporulated incompletely and after considerable delay. Other cultures appeared to remain strictly asporogenic in repeated transfers at room temperature as well as at incubator temperature. Asporogenic rods were usually enlarged, and granular, and stained irregularly.

In sterile filtrate prepared from macerated honeybee larvae, the ability to form spores was lost in some cultures but retained in others. Occasionally "variants" were produced in filtrate which differed considerably from the sporogenic form of *B. para-alvei* in morphological characteristics. Usually "variants" were produced in small numbers and at-

tempts to isolate them were unsuccessful. In a few cultures, however, the sporogenic form of *B. para-alvei* was largely replaced by a different form.

One filtrate culture inoculated with a feebly sporogenic culture of *B. para-alvei* produced a large proportion of coccoid bacterial cells. (Fig, 82, E.) From this culture two coccoid "variants" were isolated by plating. One of these was quite constant in its morphological characteristics while the other one was variable. On nutrient agar the variable coccoid grew slowly, producing raised grayish-white colonies. There was also lack of constancy in the method of cellular division; diploids, tetrads, and short chains being present in cultures prepared with a single primary colony. (Fig. 82, F.) Coccoid bacterial cells which resembled this coccoid were also seen in other filtrate cultures. The other coccoid form of constant characteristics was also isolated by plating. Morphologically this form closely resembled the coccoid bacteria usually present in recently infected larvae (Fig. 82, G), as well as the coccoid form that frequently develops in cultures from sick larvae. A large proportion of the cells in old cultures on yeast-extract egg-yolk agar were pointed or lancet-shaped, but this characteristic was less pronounced than in infected larvae at about the time of death.

A small beaded rod-form was frequently observed in cultures of sporogenic *B. para-alvei* on yeast-extract egg-yolk agar as well as in cultures in brood filtrate. Several unsuccessful attempts were made to isolate this form from cultures in which it was present in small numbers. In one series of cultures in brood filtrate, however, this "variant" developed in large numbers in two tubes. The larger rods of sporogenic *B. para-alvei* multiplied slowly and finally appeared to die out entirely without sporulating. The "variant" was isolated by plating and cultures prepared with primary colonies on bouillon agar, yeast-extract egg-yolk agar, and in bouillon broth and brood filtrate. In all these media the morphological characteristics were similar. Growth was always slow and sparse but on yeast-extract egg-yolk agar the colonies sometimes reached 1 mm. in diameter. This "variant" resembled morphologically the small beaded rods present in larvae sick of parafoulbrood. (Fig. 82, I.) Another "variant" which was occasionally seen in filtrate cultures but was not isolated appeared as long chains of short rods or coccoid cells. (Fig. 82, H.)

The coccoid form obtained in cultures from recently infected larvae (probably comparable with *Streptococcus apis* Maassen, of European foulbrood) also produced variants in culture. On a few occasions cultures which were originally derived from primary colonies have given rise to rods and spores indistinguishable from sporogenic *B. para-alvei* isolated from affected brood. Cultures in which rods and spores originated were prepared by inoculating tubes of bouillon with most of the bacterial growth from one or more old agar cultures of the coccoid form. Sporogenic rods appeared in a very small percentage of such cultures and only after incubation at 37° C. for a week or more. The manner of their origin was not determined.

On bouillon agar containing 10 per cent or more of honey morphological changes in the coccoid form occurred in some cultures but not in others. As a rule the cells were somewhat enlarged and many assumed a

lancet shape similar to the lancet-shaped cells in sick larvae. Other cells grew to medium-sized rods and some assumed a spindle shape resembling a sporulating bacillus, but the phenomenon stopped at this point. (Fig. 82, J.)

In bouillon broth to which both honey and egg yolk was added the coccoid form grew as giant coccoid cells in some of the cultures. (Fig. 82, K.) In broth alone the coccoid cells usually occurred in pairs or short chains. On yeast-extract egg-yolk agar the cells practically always occur singly after multiplication has ceased.

SUMMARY.—A variety of morphologically different bacterial forms occur in larvae sick of parafoulbrood. Changes in form of bacterial cells appear to occur as disease progresses, coccus, coccoid, and rod-shaped cells changing to lancet shapes.

Cultures from affected larvae usually yield sporogenic *B. para-alvei*. Many cultures also yield a coccoid form which resembles *Streptococcus apis*.

B. para-alvei is present in brood and stores in affected colonies. It was not found in healthy colonies or colonies with other disorders.

Under natural conditions parafoulbrood is very infectious. It is difficult to transmit to brood kept in an incubator.

B. para-alvei shows marked variability. Several "variants" were observed in these experiments, some of which were isolated and stabilized. Two of the "variants" resemble morphologically bacteria in sick larvae.

Cultures of a coccoid organism (similar to *S. apis*) obtained in cultures from sick larvae also show considerable variability. On rare occasions cultures produced a sporogenic bacillus indistinguishable from sporogenic *B. para-alvei*. Other morphological changes also occurred, depending upon the medium.

CONCLUSIONS.—The conclusions presented in this paper are intended only as tentative ones, since many questions remain unanswered regarding the role played by and the relationship of the different morphological bacterial forms present in affected larvae. These observations are presented at the present time, however, since it seems likely that many years of study may be required to obtain a thorough understanding of the disease and the bacterial forms associated with it. It appears to the writers that the evidence at hand points to a pleomorphic bacterium, of which *B. para-alvei* is a stage in the life history, as the etiological factor in parafoulbrood.

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FURTHER OBSERVATIONS ON THE FLIGHT RANGE OF THE HONEYBEE IN RELATION TO HONEY PRODUCTION

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During the summers of 1927, 1928, and 1929 a series of investigations were undertaken by J. E. Eckert[2] for the purpose of determining, among other things, the effect upon honey production of the distance bees have to fly to obtain nectar. This work was carried on near Powell, Wyo., on a large area of badlands stretching south from the irrigated district along the Shoshone River, a distance of at least 17 miles, to a small irrigated area. The only source of nectar concerned in this part of the investigation was the irrigated district along the Shoshone River, consisting of large fields of alfalfa and considerable sweetclover on either side of the river. During each of the three summers, isolated small groups consisting of 3 or 4 colonies, all as nearly uniform as possible at the beginning of the season, were placed at various distances out on the badlands, in a line at right angles to the nectar-producing area. One group was placed some distance inside the irrigated district. The colonies of bees were supplied by Mr. E. O. Rauchfuss, one of the more prominent Wyoming beekeepers, located at Powell, Wyo. Daily observations of the gains or losses in weight of the colonies at these various locations were made during certain segments of each of the three seasons. The results varied somewhat from season to season, but by averaging the data from each small group of colonies for each season the following conclusions were drawn by Eckert:[3] "Colonies located within 0.5 to 2 miles of a given source of nectar made gains in weight, over a period of three years, as great as, or greater than, similar colonies located within the same nectar-producing area, and colonies lost in weight when placed 5 miles or more from nectar."

These results were somewhat surprising, as the common opinion had been that the nearer the nectar source, the better the chances for producing a crop of honey, although a few beekeepers have been found who claim to have had an experience in line with Mr. Eckert's results. However, since the results of this experimental work were based upon the average gains in weight of small numbers of colonies for each distance group, it was decided in 1931 to carry on some experiments under actual commerical conditions, using a larger number of colonies at one location and averaging these results. By this method variations in individual colonies would, to a great extent, have less effect on the averages. These supplementary tests were started by Mr. Eckert, but, because of his resignation from the Government service, were continued during 1931

[1]These investigations were undertaken by the Intermountain States Bee Culture Field Laboratory, located at Laramie, Wyo., and maintained cooperatively by the University of Wyoming and the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

[2]Formerly Associate Apiculturist, Intermountain States Bee Culture Field Laboratory, Laramie, Wyo. Resigned July 18, 1931.

[3]Eckert, J. E. 1933. The Flight Range of the Honeybee. Jour. Agr. Research 47: 257–285, illus.

by the senior author, who was assisted during the season of 1932 by C. L. Farrar.

In the latter part of June 1931, sixty-one 8-frame colonies of bees belonging to Mr. Rauchfuss were selected by Mr. Eckert, those chosen being as nearly uniform in strength and with regard to other conditions as possible. Thirty-one of the test colonies were left in a yard containing, altogether, more than a hundred colonies located west of Powell and surrounded in all directions by fields of alfalfa and sweetclover. This

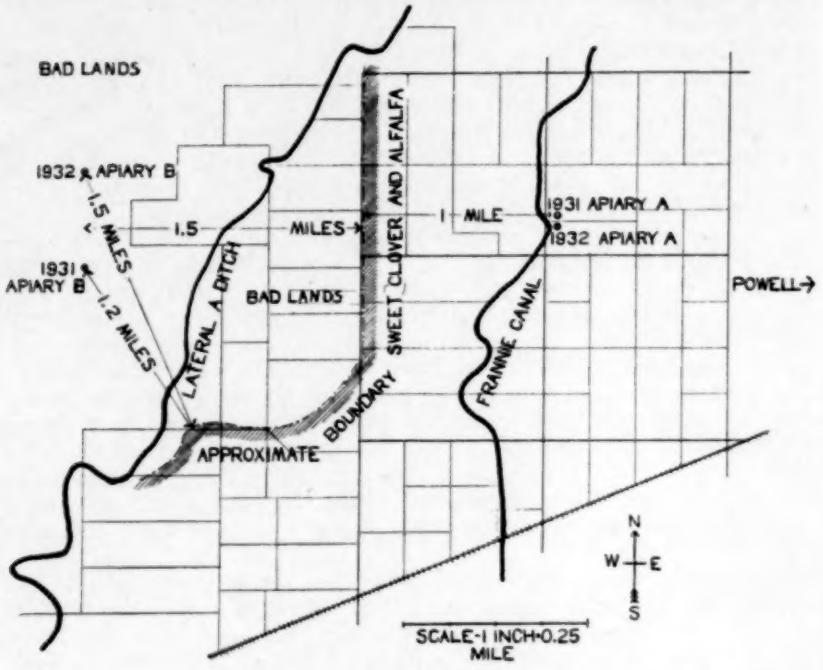

FIG. 83.—A map of the district west of Powell, Wyo., where the flight range-production studies were conducted during 1931 and 1932.

group was 1 mile east of the edge of the badlands and has been designated Apiary A, 1931. (Fig. 83.) The other 30 colonies, Apiary B, 1931, were placed almost directly west 2½ miles, or 1½ mile out on the badlands from the edge of the irrigated fields, with a gentle slope from this location down to these fields. On July 6, 1931, after the colonies had become settled in their new locations, the weight of each colony was recorded, and during the summer, as supers were added or removed, other weight records were made. Later in July it was found that the bees were flying freely to a small area of alfalfa and sweetclover to the southeast from Apiary B, 1931, as well as to the fields 1.5 miles directly east. This distance was found to be only 1.2 miles. To a great extent, however, the

bees from both apiaries were working in the same general locality. At the end of the season, on September 23, 1931, final weights were taken of the colonies.

The average net gain in weight per colony during the season for Apiary A, located within the nectar source, was 73.1 pounds; while that for Apiary B, located from 1.2 to 1.5 miles outside the nectar source, was 42.9 pounds, or 58.7 per cent as much as the gain for Apiary A. (Table 1.) In general this was a poor season in the locality around Powell.

TABLE 1. THE EFFECT ON HONEY PRODUCTION OF THE FLIGHT DISTANCE OF BEES TO A NECTAR SOURCE

Laramie, Wyo., May 18–Oct. 16, 1931

	Apiary A, 10 colonies located at edge of the nectar source *Average weight per colony, pounds*	Apiary B, 9 colonies located 1.5 miles outside nectar source *Average weight per colony, pounds*
Initial weight	69.6	75.2
Weight of equipment added	63.4	42.2
Initial gross weight	133.0	117.4
Final net weight	103.2	110.1
Weight of equipment and honey removed	238.1	160.1
Final gross weight	341.3	270.2
Net gain in weight	208.3	152.8

Powell, Wyo., July 6–Sept. 23, 1931

	Apiary A, 31 colonies located within the nectar source *Average weight per colony, pounds*	Apiary B, 30 colonies located 1.2 miles outside nectar source *Average weight per colony, pounds*
Initial weight	128.6	135.5
Weight of equipment added	8.8	8.0
Initial gross weight	137.4	143.5
Final net weight	117.0	116.1
Weight of equipment and honey removed	93.5	70.3
Final gross weight	210.5	186.4
Net gain in weight	73.1	42.9

During this same season a similar set of experiments was carried on at Laramie, Wyo., but with smaller numbers of colonies, all in 10-frame equipment and fairly uniform as to strength. Apiary B, consisting of nine colonies, was located on the campus of the University of Wyoming. These bees had to fly in a westerly direction approximately 1.5 miles to sweetclover and alfalfa fields, other nearer sources of nectar being negligible. Apiary A, consisting of 10 colonies, was placed west of Laramie and across the Laramie River, in a location on the edge of, and partially surrounded by, the same area in which the bees from Apiary B were working.

The conditions of the 1931 honey-flow in this locality were more favorable than at Powell. During the period from May 18 to October 16, 1931, the average net gain in weight per colony for Apiary A was 208.3 pounds, while that for Apiary B, located approximately 1.5 miles from the main nectar source, was 152.8 pounds, only 73.4 per cent as much as for Apiary A. (Table 1.)

Since these results seemed to be just the opposite of Eckert's findings, it was decided to repeat the work at Powell during the season of 1932.

This year 60 colonies of bees were selected for this project, again from the apiaries of Mr. E. O. Rauchfuss. A more careful check was made of each colony selected, as to population strength, condition and age of queen, number of frames of brood, and approximate brood area. The 60 colonies were then divided into two groups as nearly equivalent as possible on the basis of the above estimated factors. The first group of 30 colonies for Apiary A (surrounded by the nectar source) was placed on June 9 near the 1931 Apiary A location, but isolated from it, being placed several hundred feet to the south and separated from it by a fairly high mound. (Figure 83.) The Apiary B site was moved about one half mile north from the 1931 location so that it would be 1.5 miles to the nectar producing fields, either directly east or to the southeast. (Figure 83.) This second group of 30 colonies was also moved to its new location on June 9. On June 22, after the bees had become accustomed to their new locations, the initial weights of the 60 colonies were taken.

In the summer of 1932, as supers were added or removed, records of weight were made of each colony on June 22, July 12, August 16, and September 9. The average net gain in weight for each apiary was determined for the three segments of the season as well as for the total season. (Table 2.)

TABLE 2. THE EFFECT ON HONEY PRODUCTION OF THE FLIGHT DISTANCE OF BEES TO A NECTAR SOURCE, POWELL, WYO., 1932

	June 22–July 12 average weight per colony *pounds*	July 12–Aug. 16 average weight per colony *pounds*	Aug. 16–Sept. 9 average weight per colony *pounds*	Season total average weight per colony *pounds*
Apiary A, 30 Colonies Located Within the Nectar Source				
Initial weight	56.5	141.6	139.4	57.0
Weight of equipment added	33.6	42.1	9.4	84.6
Initial gross weight	90.1	183.7	148.8	141.6
Final net weight	141.6	139.4	160.6	160.7
Weight of equipment and honey removed	0.0	210.7	31.6	242.3
Final gross weight	141.6	350.1	192.2	403.0
Net gain in weight	51.5	166.4	43.4	261.4
Apiary B, 30 Colonies Located 1.5 Miles Outside the Nectar Source				
Initial weight	61.1	130.4	138.2	61.2
Weight of equipment added	29.5	42.7	8.0	80.2
Initial gross weight	90.6	173.1	146.2	141.4
Final net weight	130.3	138.2	145.4	145.4
Weight of equipment and honey removed	0.0	178.3	25.1	203.4
Final gross weight	130.3	316.5	170.5	348.8
Net gain in weight	39.7	143.4	24.3	207.4

Notes, Apiary A:
June 22, Brood in 5.4 deep frames and 2.5 shallow frames.
July 12, Brood in 8.1 deep frames and 3.1 shallow frames.
Aug. 16, Brood in 6.4 deep frames only.
Sept. 9, Brood in 5.5 deep frames only.
During the season 4 colonies were requeened, 3 colonies were given ripe cells, and in 8 colonies cells were cut 1 or more times.

Notes, Apiary B:
June 22, Brood in 5.8 deep frames and 2.2 shallow frames.
July 12, Brood in 7.6 deep frames and 3.0 shallow frames.
Aug. 16, Brood in 6.5 deep frames only.
Sept. 9, Brood in 5.4 deep frames only.
During the season 1 colony was requeened, 1 colony was given a ripe cell, and in 5 colonies cells were cut 1 or more times.

For the period June 22 to July 12 the average net gain in weight for Apiary B was only 77.1 per cent that for Apiary A. From July 12 to August 16 the average net gain in weight for Apiary B was 86.2 per cent

that for Apiary A. Sometime after the middle of July a grasshopper infestation moved in off the badlands onto the irrigated fields as far as the Frannie Canal (Figure 83), destroying to a large extent the alfalfa and sweetclover. The effect of this damage is seen in the records of both apiaries for the period, August 16 to September 9. (Table 2.) During this period the area available to Apiary A was cut down materially while the bees from Apiary B were forced to fly practically 1 mile farther to the nectar-bearing plants not reached by the grasshoppers, or a total now of 2.5 miles. For this period Apiary B did only 56 per cent as well as Apiary A. However, according to the totals for the season, which on the whole was much better than that of 1931, the average net gain in weight for Apiary B of 207.4 pounds per colony was 79.3 per cent that for Apiary A, 261.4 pounds. The difference between 73.4 per cent for 1931 and 79.3 per cent for 1932, however, was not sufficiently great to be particularly significant.

In the case of the outer yard (Apiary B), 15 of the supers placed on these colonies were unaccounted for after the full supers were removed. Seven of these were missing at the end of the first period and 8 at the end of the second period. Mr. Rauchfuss, who recorded the addition and removal of all supers, could only account for these missing supers on the supposition that they must have have been stolen, although there was no evidence that the yard had been molested. However, such theft was possible because of the isolated location of these colonies. Crediting this yard with an estimated average of 28 pounds net honey per missing super, the average net gain per colony for the season could be increased 14 pounds, which would bring the average net gain, compared with that of Apiary A, up from 79.3 to just under 85 per cent. This assumed adjustment, however, still does not materially change the trend in results.

The data given in the notes under Table 2 indicate, according to the amount of brood present in the colonies for the different segments of the season, that the colonies of the two apiaries did not vary significantly during the season, and that Apiary B actually had an advantage as far as necessary requeening and the swarming impulse were concerned.

Although only the one flight distance has been checked in comparison with apiaries located within the nectar source during these two seasons' observations, the indications are that apiaries located out some distance from the nectar source may not always do as well as those surrounded by a considerable area of nectar-secreting plants.

One significant fact brought out, however, was that if necessity requires the placing of apiaries appreciable distances away from the nectar source because nearer locations are unavailable, or in order to obtain a desirable protected location, other things being equal, the beekeeper can secure a quite satisfactory honey crop. It would be desirable, however, to carry out considerable more work on this general project.

AIRPLANE DUSTING AND ITS RELATION TO BEEKEEPING

By J. E. ECKERT and H. W. ALLINGER,[1] *University of California, Davis, California*

The increasing use of dusts and other insecticides in various portions of the United States for controlling insect pests is undoubtedly a major factor in the reduction of the number of colonies on farms to be noted in the United States Census reports of the past two decades. The losses sustained by the commercial beekeeper have been even greater than those of the small farmer beekeeper and will continue to increase unless definite control measures are taken to regulate certain commercial practices of airplane dusting that are fast becoming established in some agricultural regions. In the Imperial Valley of California alone over 3,000 colonies have been killed within the past four years by dusting practices, and as many more have been rendered unproductive by the destruction of their field force.

By the use of the airplane, dusts are spread over large tracts of land in a fraction of the time in which land machines could cover the same area. The drift of the poisonous dusts that always accompanies such operations constitutes a grave menace to the beekeeping industry and also, in many instances, to livestock production. Although airplane dusting is said to be in the pioneering stage, insecticides have thus been applied to forests, deciduous fruit trees, walnut groves, citrus trees, vineyards, and many crops such as alfalfa, beans, peas, tomatoes, potatoes, lettuce, watermelons, cantaloupes, and cotton. The airplane has also been used in broadcasting poisoned bran mash in the control of grasshoppers and arsenical dusts for the control of anopheline mosquitoes. A majority of the materials used in the general control of insect pests have been broadcast from the airplane, including such insecticides as cyanogas, calcium and lead arsenates, paris green, nico-dusts, sulphur, and fluosilicates, as well as dormant and summer oils and liquid sprays. The operations of the airplane companies have not been confined to large acreages of crops, for which they are best adapted, but have extended in many instances to small tracts located adjacent to or within the corporate limits of cities and in areas of extremely diversified agriculture.

When the experimental apiary of the University of California was practically destroyed, during the summer of 1934, through the application of calcium arsenate by airplane to tomatoes in the vicinity of the University Farm, a comprehensive investigation of this problem became necessary. Some of the results are given in this report.

A TYPICAL CASE OF BEE POISONING.—During the latter part of July, 1934, the experimental apiary of the University of California consisted of 54 colonies and 65 three-frame nuclei. The colonies averaged 22

[1]The chemical analyses were made by Mr. H. W. Allinger, analyst, in the Division of Chemistry, University of California, at Davis. Mr. G. H. Vansell and Mr. Frank E. Todd of the Pacific States Bee Culture Field Laboratory, Davis, cooperated with the writer in checking some of the effects of the poisoning on the colonies and discussed with him many of the phases connected therewith.

frames per hive, and each had a normal amount of brood. The bees were gathering from 2 to 4 pounds of honey per colony per day, the nectar coming primarily from alfalfa, star thistle, and mustard. The apiary of the Pacific States Bee Culture Field Laboratory, located at B in Fig. 84, consisted of 32 normal colonies, while Mr. Baker's apiary, indicated at C in Fig. 84, contained 112 colonies in flourishing condition.

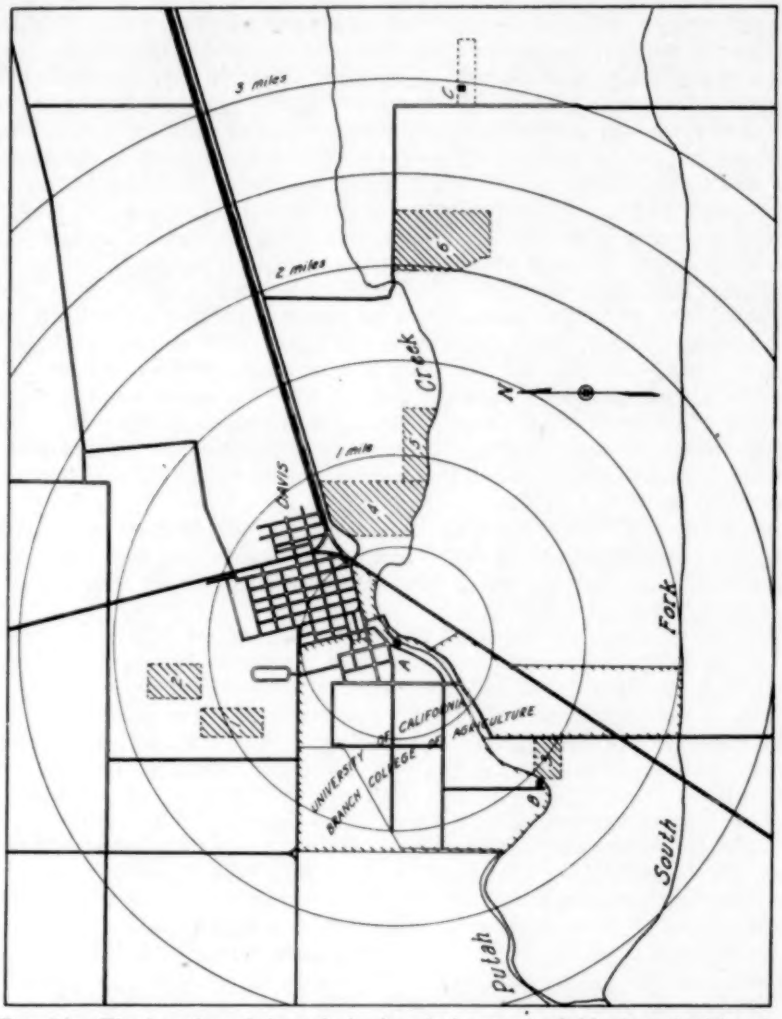

FIG. 84.—The location of the apiaries in relation to the fields dusted with calcium arsenate by airplane. *A* is the experimental apiary of the University of California; *B*, apiary of the Pacific States Bee Culture Field Laboratory; and *C*, a commercial apiary of Mr. Baker. Areas 1 to 6, inclusive, are the tomato fields, consisting of approximately 300 acres. Circles indicate distances.

On July 25 and 26 an airplane dusted 251 acres of tomatoes in the vicinity of the University Farm with 4,300 pounds of calcium arsenate. No advance notice was given to the County Agricultural Commissioner or to the beekeepers in the vicinity. The dust was applied on each of the two mornings between 5:30 and 8:30 o'clock. By the evening of the first day, numerous bees were found dead or dying in front of the entrances of the hives, and many others were crawling and hopping about. By the following morning when observations were made at 8 o'clock, thousands of bees were found crawling, hopping, or attempting to fly in all parts of the apiary and for some distances therefrom. Many were writhing in evident pain, and dead bees were scattered everywhere. The number of the dead and dying increased during the day until the ground was literally carpeted with them. Similar conditions were noted in the apiary of the Pacific Coast Bee Culture Field Laboratory, also located on the University Farm, and in the Baker apiary previously noted.

The majority of the affected bees found in the University apiary were young, some of them never having left the hive before. Only in exceptional instances were the dead bees found in large numbers in front of hives; and in these cases, weeds or roughly cultivated ground evidently had caused the accumulations. Observation showed that as a general rule, the bees left the hive on the run and then hopped and crawled, being able to fly only for short distances at a time. The activities of these bees increased with an increase in temperature, and many became lost in the grass and weeds surrounding the apiary. Often the abdomens were distended, and a condition resembling dysentery was noticed in some instances.

Each morning for the next 14 days, a new supply of dead or crawling bees was observed in the apiary, the number diminishing markedly after the second day. An increasing proportion of the bees so affected were also young bees.

An examination of the colonies in the University apiary two days after the first dusting revealed that their numerical strength had been reduced from 60 to 75 per cent. By August 6 the colonies averaged 6⅓ frames of bees per hive, only four colonies having 10 or more frames of bees each, and practically all unsealed brood had been killed. The few larvae present were very poorly fed, and many were on the point of starvation. The larvae that had died had either dried up or been removed. On later examinations, dead larvae were found in such numbers that many combs resembled those of a colony badly infected with European foulbrood. Often bees died in their cells either just before or at the time of emergence. Many black mummies of pupae were found in the combs of colonies seriously affected by arsenical poisoning.

Examinations of the dead and crawling bees, together with samples of pollen from the combs and from returning bees, indicated the presence of large amounts of arsenic (Table 1).

Our observations on the gross effect of this first exposure to airplane dusting were interrupted by a return of the same plane for further dust applications on August 11 and 12. After this second application, symptoms similar to those just described were noted in the apiaries referred

TABLE 1. ARSENIC DETERMINATIONS

Investigations of Drift from Airplane Dusting of Tomatoes with Calcium Arsenate, Including Analyses of Plants, Bees, and Pollen Affected by the Arsenate.
(The lethal dose of arsenic for a bee is approximately one-half part per million.)

Sample No.	Field No.	Time of dusting	Time of sampling	Kind of sample	Location of sample	Dry wt. sample (grams)	Arsenic found as $Ca_3(AsO_4)_2$, p.p.m.
1.....	2	8-11	8-11	Alfalfa	From field adjoining No. 2	10	1415
2.....	2	8-11	8-11	Morning glory	From field adjoining No. 2	2.1	290
3.....	2	8-11	8-11	Alfalfa	200 yards from field No. 1	8.5	85
4.....	2	8-11	8-11	Morning glory	Along ditch bank west of field 2	3.0	505
5.....	2	8-11	8-11	Alfalfa	400 yds. west of field 2	11.5	27
6.....	5	8-12	8-12	Star thistle	Along roadway, ¾ mile from field 6	7.5	19
7.....	5	8-12	8-14	Mustard	From field 6	8.0	315
8.....	2	8-11	8-15	Alfalfa	From field adjoining No. 2	5.9	27
9.....	2	8-11	8-15	Alfalfa	200 yds. from field No. 2	5.0	566
10.....	5	8-12	8-17	Mustard	From field 6	3.0	86
11.....	4	8-26	8-26	Star thistle	3/10 mile from field 4	5.0	31
12.....	4	8-26	8-26	Star thistle	Along roadway near field 4	6.5	435
13.....	5	8-26	8-26	Morning glory	87 blossoms from field 5	1.2	304
14.....	5	8-26	8-26	Mustard	Near edge of field 5	4.0	757
15.....	4	8-26	8-27	Star thistle	2/10 mile from field 4	7.0	21
16.....	5	8-26	8-27	Mustard flowers only	Near field 5	1.4	540
17.....	4	8-26	8-27	Star thistle blossoms only	2/10 mile from field 4	2.0	3,535
18.....	5	8-26	8-28	Mustard	Near field 5	2 0	170
19.....	4	8-26	8-28	Star thistle heads	Roadside near field 4	7.0	260
20.....	4	8-26	8-29	Star thistle blossoms only	Near field 4	3.2	753
21.....	–	——	8-12	Pollen	Collected from bees at hive entrances	2.8	6
22.....	–	——	8-20	Pollen	From combs of scale hive	5.5	92
23.....	–	——	8-20	Crawling bees	University apiary	2.6	39
24.....	–	——	8-21	Crawling bees	In front of hives	2.2	46
25.....	–	——	8-22	Pollen	From combs	5.0	24
26.....	–	——	8-27	Dead bees	In front of hives	1.8	140
27.....	–	——	8-27	Crawling bees	University apiary	1.9	48
28.....	–	——	8-27	Pollen from bees	Collected between 8:00 and 8:45 a.m.	0.3	1
29.....	–	——	8-27	Bees	Pollen bearers between 8:00 and 8:45 a.m.	1.8	28
30.....	–	——	8-27	Pollen from bees	Collected between 9:15 and 9:30 a.m.	0.5	80
31.....	–	——	8-27	Bees	Pollen bearers between 9:15 and 9:30 a.m.	1.5	27
32.....	–	——	9-1	Crawling bees	In front of hives	5.0	13
33.....	–	——	9-1	Pollen	From combs	6.0	16
34.....	–	——	9-3	Pollen	From combs	4.4	22
35.....	–	——	9-3	Pollen	From combs	5.4	45
36.....	–	——	9-3	Pollen	From combs	2.5	3
37.....	1	8-31	8-31	Glass plate 18"x30"	¼ mile from east field 1	1.33	5
38.....	2	8-31	8-31	Glass plate 18"x30"	20 yds. from field 2	5.86	22
39.....	2	8-31	8-31	Glass plate 18"x30"	70 yds. from field 2	5.30	20
40.....	2	8-31	8-31	Glass plate 18"x30"	120 yds. from field 2	3.73	14
41.....	2	8-31	8-31	Glass plate 18"x30"	170 yds. from field 2	4.26	16
42.....	2	8-31	8-31	8 glass plates 5"x7"	First 20 yds. from edge of field; others at 20-yd. intervals in field 2	33.50	63

to. The symptoms were not so noticeable, however, because there were fewer bees in the colonies and because the majority were young bees. A day before the second application of the dust, we had secured 10 additional colonies in order to start some of our experimental work anew. The second applications were also made without any advance notice to the beekeepers in the vicinity, although the dusting company had been notified of the damage wrought immediately after the first visit.

The same plane returned on two later occasions for additional applications, each field receiving an average of three treatments of calcium arsenate.

By October 4, the University apiary had been reduced to 28 colonies, only 8 of which were strong enough to pass the winter, and 3 nuclei which were given the same doubtful opportunity. The balance of the colonies, about 20 in number, were considered too weak in number of bees to winter, and these were strengthened by the addition of package bees in order to determine how the exposure to poisoning would affect their queens. (The belief that such queens are worthless is held quite generally by beekeepers whose colonies have been similarly affected.) Apiary B had lost 10 colonies and had the remainder considerably weakened, while apiary C had 102 colonies either killed outright or so weakened that it was doubtful whether they could live through the winter period.

The monetary loss to the three apiaries caused by this airplane-dusting episode was estimated to have been around $1,590.00, with the possibility of more colonies dying during the winter period.

How Bees May Get the Poison, and Some of the Effects.—When plants are dusted while in bloom, the honeybees may be poisoned by getting the poison from the nectar or from the pollen. Water carriers are also poisoned if they collect condensed moisture from plants that have been dusted or sprayed. As bees lose the power of flight soon after they ingest arsenic, the nectar and water gatherers are seldom able to return to their hives. Consequently, the honey in hives whose colonies were most seriously affected did not kill bees when it was fed to them in cages. The pollen bearers, on the other hand, collect the poison with the pollen on their legs and body hairs and carry it back to their hives. They are not killed while doing so unless they collect nectar at the same time. This poisoned pollen, if stored in the combs, forms a source of danger to nurse bees when they attempt to elaborate food from it for the larvae.

The controlling impulse of a hive bee after ingesting arsenic is to leave the hive in an attempt to void the material from its intestinal tract. Consequently, the nurse bees so affected leave the hive under this impulse and die. That they do so before feeding the poisoned food to the larvae is borne out by the fact that queens receive much the same food as the younger larvae direct from the nurse bees and none of the queens in the University apiary were killed by poisoning. The queens generally remained to the very last or swarmed out with only a handful of bees. The larvae in poisoned colonies must therefore die of exposure and starvation after the nurse bees and fielders have been killed.

A 50-acre field immediately across the road from apiary C had been planted to tomatoes for three years in succession up to 1934 and had been dusted heavily each year with calcium arsenate by land machines without any noticeable injury to bees. Tomatoes have also been raised in a field adjacent to the apiary on the University Farm and have been dusted each year with calcium arsenate by hand machines without any apparent damage resulting. Poisons in various forms have been applied

by surface machines on the University Farm for years in the experimental control of weeds and injurious insects without damaging the bees. As bees are not attracted by tomato blossoms, they visit tomato fields only for the pollen and nectar that they may get from occasional weeds growing therein. All tomato fields shown in Figure 84 contained considerable morning glory; but dusting was done, generally, before these blossoms opened. Although some mustard was present in field 3, this plant was removed immediately after the first dusting. Evidently, therefore, the major damage resulting to the bees in the present instance was caused by poisons that drifted, during the operations, outside the treated fields to nectar and pollen-producing plants on which the bees were working. Chemical analysis of numerous samples of these plants collected from different parts of the territory over which the dust was seen to drift indicated the presence of large amounts of arsenic wherever the samples were taken (Table 1).

THE COLLECTION AND ANALYSIS OF SAMPLES.—Blossoms of morning glory (*Convolvulus arvensis* L.), yellow star thistle (*Centaurea solstitialis* L.), mustard (*Brassica* spp.), and alfalfa (*Medicago sativa* L.) were collected in order to determine the extent of the drift from the fields treated. The blossoms were collected in fields dusted and for three-quarters of a mile around. Samples of crawling and dead bees, of pollen from field bees, and of pollen from the combs of affected colonies were likewise analyzed. All samples of plants were dried before analysis, and calculations were made on the dry-weight basis. In cases where the attempt was made to ascertain the amount of arsenic ingested by the insects, the bees were washed 12 times with 1 N. HCl to remove adhering arsenate. The final washings showed but a faint trace of arsenic. All analyses were made according to the Methods of Analysis, A. O. A. C., 3rd edition, 1930.

Samples of the drifting dust were collected on glass plates 18x30 inches in size that were vaselined and placed from 20 to 440 yards from a field during one of the applications. Eight vaselined glass plates, 5x7 inches in size, were placed between rows of tomatoes in the same field at intervals of 20 yards. Contrary to expectations, the plane flew at right angles instead of parallel to the rows and hence flew parallel to the row of plates. It was not observed whether the plane passed directly over the plates in the field or to one side of them. The dust was deposited more densely beneath the center of the plane than elsewhere.

RESULTS OF THE ARSENIC DETERMINATIONS.—The analyses of the samples of bees indicated that both the dead and the crawling bees contained large quantities of arsenic, many times the lethal amount. This is evidence not only of the cause of their death but of the acuteness of the stimulation that would make the bee leave its hive.

The analysis of the pollen samples from combs of colonies affected showed the presence of 3 to 92 parts per million of arsenic. These samples, taken at random from the combs, evidently included pollen that had been stored there before the dusting operations began. The amount of poison present, however, is evidence of the manner in which the nurse bees were killed and the danger of the combs to bees until the poisoned

pollen is removed. In samples number 16, 17, and 20, in which only the flowers were examined for arsenic, the amount of arsenic present was greater than the average amount found in samples in which small portions of the plants were included with the blossoms.

The amount of arsenic deposited on the vaselined plates was enlightening in many ways. Approximately 12 pounds of arsenic per acre was applied to the fields from which these samples of drift were collected. If this amount is spread evenly over a level surface, there will be approximately 86.2 milligrams of 70 per cent calcium arsenate on each square foot. The plates placed in the field caught only 33.50 milligrams of calcium arsenate per square foot, a discrepancy of 52.7 milligrams from the theoretical amount. The plate placed 20 yards from the field caught 5.86 milligrams of calcium arsenate per square foot, whereas the others located 70, 120, and 170 yards distant caught 5.30, 3.73, and 4.26 milligrams per square foot, respectively. The plate located 440 yards from field number 1 caught 1.33 milligrams of calcium arsenate per square foot. The amounts of arsenic caught on the plates located outside the field are definite proof that a very appreciable amount of the dust drifted from the field and support the evidence of the plant samples that the drift constitutes a major menace to bees and livestock when arsenate dust is applied by airplane.

Emergency Measures to Prevent or Mitigate Injury to Bees.—It is evident from the facts here presented that *had the dusts been confined to the fields to which they were applied, the injury to bees would have been negligible*. The mustard in the tomato fields was not general enough to present a major hazard, and any injury from this source would have been reduced had the weeds been removed before the dusts were applied instead of afterward. Clean cultivation in the fields to be treated would therefore tend to mitigate injury to bees caused by the direct application of the dusts.

Since the beekeepers were not forewarned of either of the first two applications, the greater portion of the damage was done before any one was aware of what was taking place. No opportunity was given to remove the colonies from the territory. As the next best expedient to moving, some of the colonies in the University apiary and all colonies in the apiary of the Pacific States Bee Culture Field Laboratory were closed from daylight to around ten o'clock on the days when the dusts were applied, with the exception of the first applications, and for the same length of time on four or five days thereafter. It was noted by Mr. Vansell, of the Pacific States Bee Culture Field Laboratory, that the majority of the pollen was brought into apiary B before ten o'clock in the morning. Closing the entrances of the hives would therefore tend to reduce the amount of the poisoned pollen carried in and to prevent the field bees from getting poisoned nectar during the same period. On account of the high temperature that prevailed, the colonies could not be closed for longer periods without danger of suffociation.

The combs containing poisoned pollen in the University apiary were removed after the first application of dust. As the second application was made without warning, however, and the treated colonies again

secured some poisoned pollen, the results of this treatment could not be ascertained. Combs containing poisoned pollen were again removed from the hives in the University apiary after the applications of dust had been completed and were soaked in water for 48 hours. The pollen stores in combs thus soaked shrink upon drying and can be removed by bees. In average practice, according to the experiences of beekeepers in the Imperial Valley, brood combs taken from hives of colonies killed by dusting practices will cause the death of colonies to which they are given unless the combs are first freed of the pollen.

CONCLUSIONS.—Poisoning of bees is increased by the use of chemical dusts in insect control because the honeybee collects the dusts along with the pollen and stores the poisoned pollen in its combs. This poisoned pollen then constitutes a source of poison for the nurse bees as they elaborate food for the larvae. Dusts also have a much greater tendency to drift with the wind when applied by airplane.

Field bees gathering poisoned water and nectar are incapacitated in the field and therefore do not deposit their poisoned loads in the combs. The nurse bees in colonies seriously affected by dust poisoning generally die outside the hive and before they have an opportunity to feed the larvae or queen the food that they attempt to elaborate from poisoned pollen. For this reason, larvae in poisoned colonies generally die of starvation and exposure, and the queens are generally the last of the bees to disappear.

Combs should be freed of poisoned pollen before they are given to other colonies. This can be done by soaking the combs in water for 48 hours, after which the pollen shrinks upon drying and is removed by the bees.

Moving bees from poisoned areas, although costly, will prevent injury. Confining the bees to their hives for certain periods during and after dusting may tend to mitigate the injury to the colony.

Clean cultivation to remove certain weeds from the field dusted will also tend to reduce the amount of injury to bees.

As the blossoms of field tomatoes are not attractive to the honeybee, fields of tomatoes in the vicinity of apiaries have been dusted repeatedly with calcium arsenate by means of land machines without any noticeable injury to bees.

Analyses of plants, bees, and pollen for arsenic as well as samples of the dust that drifted from the fields treated indicated that the damage to the apiaries in question was caused by the poisons that drifted to the plants from which the bees gathered pollen and nectar.

RESISTANCE OF HONEYBEES TO AMERICAN FOULBROOD

By R. G. RICHMOND, *Ft. Collins, Colorado*

Prior to the commencement of the experiments mentioned herein, it had been brought to the attention of the author that some colonies of bees appear to have the ability to recover from an attack of American Foulbrood. The evidence behind these statements lacked proof, in that

there had been no bacteriological diagnosis of the cases mentioned. To prove or disprove these statements, this research was undertaken.

In June 1929, 16 colonies of bees were established west of Ft. Collins, fifteen miles from the city, in Rist Canon. The location is behind a rather rugged foothill barrier, separating bees in the location rather definitely from those of the plains. There were no so-called "wild bees" in the vicinity, since the honey production of this isolated valley is inadequate per colony per year for year round support.

Four of the above mentioned colonies were of the ordinary run of Italian stock and twelve were of the Rauchfuss strain of Caucasian.

By July 1929, these colonies had become fairly well established. Inspection at this time revealed no evidence of American Foulbrood. During this month all colonies were fed a suspension of spores of Bacillus larvae in a five per cent sugar solution. One larval scale was macerated in the syrup for each colony. There was a light honey flow in progress during the feeding. Subsequent observations in 1929 revealed one Italian and two Caucasian as having contracted the disease.

During the winter of 1929–30, a severe one, six colonies failed to survive. They were replaced in June with packages, three pounds of bees and a queen, except one Italian, replaced by a full colony. At this time, none of the overwintered colonies showed any disease.

During June, each colony was given a section of diseased comb about two by three inches and containing the scales of at least fifty larvae dead of American Foulbrood. These sections were inserted in a central comb, so that the insert was as close to the center of the brood nest as possible. One-half of the colonies were given comb from the northern part and the other half, comb from the southern part of the state.

In a few days, it was noted that some of the colonies had removed part of the diseased comb, in one or two cases almost to the midrib of the comb.

On July 2, 1930, all but two Italian colonies showed marked indications of A. F. B. It is well to note here that these two colonies remained healthy throughout the experiment for three years. Some colonies, at this time showed fifty or more diseased cells, others only a few. Most of the diseased larvae were found in combs immediately adjoining the innoculating comb, indicating that honey had been placed in the diseased cells and later used as brood food.

On August 1, 1930, duplicate slides from diseased larvae of each diseased colony were made for bacteriological examination. One set was sent to the U. S. Bee Culture Field Laboratory at Laramie and the other is on file at the office of the State Entomologist at Ft. Collins. Dr. Sturtevant, of the above mentioned laboratory examined the slides and pronounced them heavy with spores of Bacillus larvae. At this time all but three of the colonies contained at least fifty cells containing larvae newly dead of A. F. B. None of the counted cells lay within the area of the innoculating section of comb.

During the later part of the summer, six Caucasian and one Italian became so badly diseased that they died during the early winter and were removed.

During the summer of 1931 some colonies became gradually worse while others improved so far as health was concerned. It is not necessary to report herein on the progress of each individual colony since those colonies of apparent value are recapitulated, in their history and progress, farther on in this report.

On June 1, 1932 there remained alive five colonies, the two Italians that did not contract the disease and three Caucasians, numbers 1, 4 & 6, the former two healthy and number six with over fifty cells with dead larvae in two frames.

During the summer of 1931, the queen of number 4 disappeared and the colony was given a frame of brood from number 6. From this brood a cell was raised and a queen successfully mated.

Of the five colonies still alive in 1932, the following summary of the progress of the disease is noteworthy.

Colonies B & C, Italians, have shown no evidence of the disease

Colony 1—Caucasian
July 2, 1930—evidence of A. F. B.
Aug. 1, " —2 cells in 2 frames
June 1, 1932—no evidence since previous date

Colony 4—Caucasian
July 2, 1930—evidence of A. F. B.
Aug. 1, " —more than 50 diseased larvae in 3 frames
June 15, 1931—3 diseased larvae
July 10, " —1 diseased larva
Aug. 5, " —no sign of diseased larvae
Sept. 2, " — " " "
June 1, 1932— " " "

Colony 6—Caucasian
July 2, 1930—evidence of A. F. B.
Aug. 1, " —14 diseased larvae in 2 frames
June 15, 1931—no evidence of disease
July 10, " — 9 cells with diseased larvae
Aug. 5, " —23 " " "
Sept. 2, " —40 " " "
June 1, 1932—more than 50 diseased larvae in 2 frames

It is of interest to note that of all of the colonies that contracted A. F. B., those that were innoculated with the strain of Bacillus larvae from northern Colorado had died before June 1, 1932. Of the Caucasian colonies innoculated with the diseased material from southern Colorado, fifty per cent were alive on the above date. Two of these latter colonies, numbers 1 & 4, were apparently healthy on the above date, while the other, number 6, was not in serious condition as regards a drain on colony strength due to A. F. B. During the summer, colony 6 became steadily worse and in the autumn was so badly decimated by A. F. B. that it was decided to destroy it.

Colonies 1 & 4 did not attain great strength during the summer of 1932, due to a very poor season, and since they were apparently healthy, it was decided to return them to the college apiary in Ft. Collins. Both of these colonies were short of stores at this time and were given combs of honey on their new location.

Colony 1, failed to survive the winter as had been anticipated. Steps might have been taken to save it, but the plans were originally to inter-

fere as little as possible with these colonies in so far as the strain of bees in each colony was concerned.

Colony 4 survived the winter in good condition. Examination of the brood June 5, showed no evidence of A. F. B. Further observations, a week later, showed four larvae dead of A. F. B. Examinations throughout the summer revealed 2 to 6 cells with larvae dead of the disease on each occasion. The colony went into winter quarters in fair condition.

It is recalled, at this point, that this colony, number 4, Caucasian, was headed at this time with a queen daughter of the queen of number 6, which latter colony secumbed to A. F. B. in the autumn of 1932.

Colony number 4 survived the winter of 1933–34 in good condition. No examination took place until the dandelion flow was well under way. Examination on May 29, 1934 disclosed no evidence of A. F. B. Monthly examinations throughout the summer, to and including September, showed that the colony was apparently healthy, with regard to American foulbrood.

The case history of this colony is recapitulated herewith.

June		1930—Colony given section of comb containing 50 scales of larvae dead of A. F. B.
July	2,	" —Evidence of newly diseased larvae
Aug.	1,	" —More than 50 cells containing diseased larvae in three frames
June	15,	1931—3 cells with diseased larvae
July	10,	" —1 cell " " "
Aug.	5,	" —No evidence of diseased larvae
Sept.	2,	" — " " " "
June	1,	1932— " " " "
Later,		" — " " " "
June	5,	1933— " " " "
"	12,	" —4 cells of diseased larvae
Later,		" —Several examinations revealed 2 to 6 cells containing larvae dead of A. F. B.
May	29,	1934—No evidence of diseased larvae
June	11,	" — " " " "
July	3,	" — " " " "
Later		" —Several examinations disclosed no evidence of infection

Colony number 4 has gone into the winter of 1934–35 with a queen more than three years old. The general condition of the colony is fair. In the 1934 production season it stored about 75 pounds of honey including about thirty pounds of comb honey as compared to an apiary average of 130 pounds.

It is not concluded from the evidence presented herein, that this surviving colony of the original sixteen is free of American foulbrood but it is evident that it has some power of combating the disease. Nor is it concluded that there is any evidence of a physiological immunity.

The manner of removal of the diseased, dead larvae, by the bees, is worthy of note. It was repeatedly observed that the lower side walls, of the cells containing dead, diseased larvae, were cut away by the bees. The cut away material was apparently thrown out by the bees and the cell walls repaired. Since first making this observation the same phenomenon has been observed in the field in many cases; that is to say many colonies have been observed with this "cut away" cell appearance,

so that there may be a greater effort, on the part of the bees, to remove dead, diseased larvae, than we have noted in the past.

In so far as the Italian colonies are concerned, it should be explained that those colonies which did not contract the disease, in the beginning, were those colonies which cut the inoculating pieces of comb down to the mid-rib. Possibly the bees considered the introduced piece of comb foreign or objectionable or unstable in its method of introduction into the original comb.

If any evidence of immunity is presented in the discussion of these experiments, the author considers it a "mechanical" immunity, in that the bees simply remove the objectionable material from the hive by mechanical means. It seems bacteriologically impossible that the bees could remove all of the Bacillus larvae organisms, but, it is also doubtful if that be necessary. Sturtevant (1) has pointed out that the apparent minimum infectious dose of B. larvae spores for a colony of bees seems to be fifty million spores in one liter of sugar syrup. If this be the case, it is apparent that it would not be necessary for the bees to remove nearly all of the spores of a dead, diseased larva to bring that cell within the margin of safety.

It is evident from this progress report that it may be possible to secure a strain of bees which will, in the future, not be ravaged by American foulbrood to the present extent. It is also evident that the investigation must be broadened many times its present extent. Instead of using a few colonies, as in this experiment, two to five hundred colonies would furnish a more appropriate field in which to work. The value, to the beekeepers of the world, cannot be estimated and there seems to be no question but that a strain of bees may be secured which will be resistant, at least in some measure, to American foulbrood.

1. STURTEVANT, A. P. 1932. Relation of commercial honey to the spread of American foulbrood. Jour. Agr. Research 45: 5, 257–285.

Section of Extension

RECENT DEVELOPMENTS IN THE USE OF ARSENICAL SUBSTITUTES FOR VEGETABLE PEST CONTROL IN NEW YORK[1]

By H. C. Huckett and G. E. R. Hervey

Interest by growers in the use of arsenical substitutes on vegetables is increasing in New York, largely incidental to local experiences with the arsenical residue problem. Those most affected thereby are growers of cauliflower, cabbage, brussels sprouts, broccoli, and green beans. At present chief reliance is being placed on the use of derris and cubé dust mixtures. An occasional brand offered for sale has, in addition, a small quantity of pyrethrins. The active ingredients of such mixtures are usually given in terms of percentage rotenone content. This varies with different brands from 0.4 to 1 per cent, a so-called general purpose dust averaging 0.6 to 0.8 per cent rotenone content. There is apparently, as yet, no recognized scale of prices for rotenone containing dusts. The cost to the grower has been from 9 to 20 cents per pound, and the figure has been found to be not necessarily related to the amount of rotenone or toxic ingredients present. An average price for a dust mixture of 0.7 to 0.8 per cent rotenone content has been in 1934 from 12 to 14 cents per pound.

Experimental work with arsenical substitutes has largely been focused on the problem of pest control on cabbage and cauliflower. Investigations have so far been carried on chiefly in western New York by Hervey and Dr. Hugh Glasgow, and on Long Island by Huckett. After preliminary tests in 1933 with many materials of a nonarsenical nature, experiments have more recently been confined to the use of derris and cubé as insecticides. In general, the results from both localities have closely corroborated one another. These may be briefly summarized as follows:

Dust mixtures containing either powdered derris or cubé root, prepared from roots having nearly the same average rotenone and total tubatoxin content,[2] compared favorably in effectiveness with one another when used against cabbage worms. The differences in results obtained with mixtures of 0.5 to 1 per cent rotenone content were small and variable, indicating that the weaker strength is satisfactory for practical purposes and for reasons of economy would be preferable to the 1 per cent mixture. All were superior in effectiveness to dusts of 0.33 per cent rotenone content. Talc, clay, finely ground gypsum, and sulfur-clay were satisfactory diluents or carriers.

[1]Approved by the Director of the New York State Agricultural Experiment Station for publication as Journal Paper No. 71, Dec. 22, 1934.

[2]Such samples showed an analysis of 5.3 per cent rotenone and 21 per cent total extractives for derris root, and 5.1 per cent rotenone and 20 per cent total extractives for cubé root, and were kindly furnished by the firm of W. Benkert and Co., Inc., New York City, for investigations on Long Island.

Spray mixtures containing derris powder were slightly more effective than those containing cubé powder. Neither were quite as effective as derris or cubé in dust mixtures. Spray mixtures containing 3 to 4 pounds of powdered derris root of 5 per cent rotenone content per 100 gallons with a suitable spreader gave most promising results. Liquid neutral cocoanut oil soap 5 quarts, penetrol 2 quarts, or powdered skimmilk 4 pounds per 100 gallons of spray made satisfactory spreaders. In one series of experiments acetone extracts of derris root of 5 per cent rotenone strength, combined with soap as a spreader, gave about as satisfactory results as powdered derris root in a spray mixture. The actual strengths compared were 1½ quarts of extract and 3 pounds of root of 4 per cent rotenone content in 100 gallons of spray.

It has usually been observed that the cabbage looper is more difficult to control than the other green worms on cabbage, such as the imported cabbage worm and the diamond-back moth, but whether this is due to a difference in actual immunity to the poison, to a matter of differences in feeding habits, or to other differences, is not known. The zebra caterpillar has been practically unaffected by applications of derris, cubé, or pyrethrum powder. This has apparently been strikingly indicated on Long Island by the sudden prevalence of this pest during the past two years when arsenicals were not used to control worms. Likewise cabbage aphids were not satisfactorily controlled by derris or cubé dust mixtures. In both instances, however, the pests were conveniently controlled by spot dusting with 3 to 4 per cent nicotine-lime mixtures, without interfering with the efficacy of derris or cubé treatments for green worms.

Preliminary tests in the use of derris and cubé have been made with other insects under field conditions with varying results. Derris and cubé spray and dust mixtures at strengths comparable to those used to control green worms on cabbage and cauliflower have shown promising results when applied for the control of thrips (*T. tabaci* Lind.) on cauliflower seedlings and for the control of the Mexican bean beetle on lima and snap beans. In both instances it was thought best for the sake of effectiveness to apply the dusts during the evening in anticipation of a more or less extended period of high humidity. Neither derris nor cubé were satisfactory for use against the corn ear worm.

SUMMARY OF RESULTS OBTAINED WITH ARSENICAL SUBSTITUTES FOR THE CONTROL OF VEGETABLE CROP INSECTS AT THE VIRGINIA TRUCK EXPERIMENT STATION

By HARRY G. WALKER and LAUREN D. ANDERSON

Derris and pyrethrum dusts have been tested for the control of the following vegetable crop insects at the Virginia Truck Experiment Station:

1. Cabbage worms. In 1933, a derris dust containing 0.5 per cent rotenone and a pyrethrum dust containing 0.3 per cent pyrethrins gave

satisfactory control of the cabbage looper, *Autographa brassicae* Riley, and of the larvae of the diamond backed moth, *Plutella maculipennis* Curtis; while dusts containing 0.25 per cent rotenone and 0.1 per cent pyrethrins did not give satisfactory control. In 1934, under conditions of very heavy infestation of the larvae of the diamond backed moth on heading broccoli, it required from 40 to 50 pounds per acre of a derris dust containing 0.75 per cent rotenone, applied with a traction duster, to control this pest. There did not appear to be very much difference between the effectiveness of gypsum, talc, an inert clay, or a finely ground tobacco dust when used as carriers for derris for the control of cabbage worms. A bentonite carrier did not appear to give quite as satisfactory results as the other carriers. The addition of 5 per cent by weight of finely ground dusting sulphur seemed to improve the effectiveness of a derris-talc dust. Based on rotenone content, a cubé dust did not seem to give quite as satisfactory control of cabbage worms as did a derris dust.

2. Cucumber beetles. Promising results have been obtained with a derris-gypsum dust containing 0.5 per cent rotenone for the control of the striped cucumber beetle, *Diabrotica vittata* Fabricius. Gypsum gave slightly better results than talc when used as a carrier with derris for the control of this insect.

3. Corn earworm. Derris and pyrethrum dusts had practically no effect on the corn earworm, *Heliothis obsoleta* Fabricius.

4. Mexican bean beetle. Bean growers report obtaining very satisfactory control of the Mexican bean beetle, *Epilachna corrupta* Mulsant, with a derris dust containing 0.75 per cent rotenone applied at the rate of 15 to 20 pounds per acre and some growers reported getting good control with as little as 10 pounds of dust per acre.

5. Potato flea beetle. Very high kills of the potato flea beetle, *Epitrix cucumeris* Harris, have been obtained with derris dusts containing 0.5 per cent rotenone, but only slight increases in yield were obtained by dusting heavily infested potato plants with as many as six applications at seven to ten day intervals.

6. Onion thrips. Derris dusts containing 0.5 and 0.75 per cent rotenone appeared to give very good control of the onion thrip, *Thrips tabaci* Lindeman, early in the season, but as soon as the infestation became very severe on the check plats and on other crops, the thrips migrated in so fast that the derris dusts failed to keep them under control on onions.

7. Squash bugs. On two different occasions, adult squash bugs, *Anasa tristis* De Geer, migrated into small fields of young squash and in each case one dusting of the infested plants with a derris dust containing 0.5 per cent rotenone gave very successful control. However, no tests have been conducted under conditions of heavy infestation or where all stages of the insect were present.

8. Harlequin bugs. Thoroughly dusting Harlequin bugs, *Murgantia histrionica* Hahn, with a derris dust containing at least 0.5 per cent rotenone usually gives better than 75 per cent kill. However, in our tests the results have been somewhat erratic, with the dust failing to give more

than 25 per cent control on certain occasions. The exact cause of all this variation has not been determined, but cool windy weather seems to greatly reduce the effectiveness of the dust. This material is not entirely satisfactory, but when thoroughly applied, it has given better results than any other material that we have tested. Pyrethrum dust containing nearly 1 per cent pyrethrins paralyzed the bugs temporarily, but they soon recovered and apparently suffered no ill effects from the dust.

9. Aphids. Several species of aphids (*Brevicoryne brassicae* Linn., *Illinoia solanifolii* Ashmead, and *Myzus persicae* Sulzer) have been dusted with derris and pyrethrum dusts in the field on various occasions, but so far these dusts have failed to give satisfactory control.

DERRIS AS AN ARSENICAL SUBSTITUTE ON VEGETABLES

By THOMAS J. HEADLEE, *Entomologist, New Jersey Agricultural Experiment Stations*

Experimental work on derris for treatment of insects injurious to vegetables has been going on at the New Jersey Agricultural Experiment Station for several years. Practical use of derris in the dust form against vegetable insects reached its highest point during the season of 1934 in which about 50 tons of ground derris dust mixture was used on various vegetable crops. The bulk of this consumption occurred in connection with the control of the Mexican bean beetle.

During the season of 1934 the following materials were studied against the Mexican bean beetle: (1) home mixed derris dust containing 25 parts of 4% rotenone and 75 parts of talc; (2) derris dust containing 16 parts of ground derris running 5% rotenone and 18% total extractives, 25 parts of fine ground dusting sulfur and 59 parts of fine ground clay; (3) derris dust containing 16 parts of ground derris root, running 5% rotenone and 18% total extractives, 20 parts Coposil and 64 parts of talc; (4) a dust consisting of a fine grade of gypsum impregnated with derris extract in amounts sufficient to give 0.5% rotenone; (5) a similar dust made in the same way so as to carry 0.75% rotenone; and (6) a similar dust made so as to contain 1% rotenone. Each of these different dusts were used on beans in one-seventh acre blocks. Two applications were made before the beans were picked for market.

The materials made up with ground derris dust were much more effective in reducing the feeding injury to foliage than the materials composed of impregnated dusts. The plants treated with ground derris dusts showed about 10% of the foliage eaten at the time the beans were harvested while the impregnated materials showed from 30 to 60% of the foliage destroyed. A study of the beetles returning to the treated blocks showed reinfestation of the impregnated material treatments first and later the ground derris dust treatments. Furthermore, the last of the ground derris dust materials to be reinfested was the derris-sulfur-clay combination indicating that this particular derris dust seemed to have a much greater residual effect than any of the others.

These materials were applied by means of a two-row duster, using metal single row hoods. These particular metal hoods were 6 feet long, 12 inches wide and 14 inches high. The use of these hoods made it possible to effect satisfactory coverage and to secure complete kill by the use of 10 pounds of dust per acre as compared with 25 to 30 pounds per acre when applied without the hoods. In view of the fact that the derris dusts were sold to the consumer at the rate of from 18 to 22 cents per pound the resultant saving made the use of the hoods very attractive. Moreover by the use of the hoods it became possible to apply the dust materials in the presence of a considerable wind movement instead of having to work in the early morning or late evening or at night as was the case where no hoods were used. These single-row hoods were developed many years ago for use with nicotine dust and are described in circular 311 of the New Jersey Agricultural Experiment Station.

The use of derris dusts with the hoods was demonstrated throughout the snap bean growing sections of New Jersey. A number of growers constructed similar hoods for their dusters and apparently found them satisfactory.

Experiments were carried out on the use of derris dust on cabbage and cauliflower for control of the cabbage looper, imported cabbage worm and the caterpillar of the diamond back moth. The results obtained corroborated the results obtained in 1933 and showed that a derris dust containing 0.8% rotenone and 2.8% total extractives is the most economical and practical form. This dust consists of 16 parts of ground derris (5% rotenone and 18% total extractives), 25 parts of sulfur and the balance clay or talc. Fifteen to 18 pounds per acre were required without hoods and from 8 to 10 pounds were necessary when applied with hoods.

Enough experience and study has been given to the control of the tomato horn worm to demonstrate that derris dust has a definite place in the tomato production program against this insect. The second brood of the horn worm appears in the canhouse tomato fields about the time the first fruit is ripening. It has been the practice heretofore to cover the foliage with calcium arsenate and to depend upon the canner to remove the fruit residue by washing. The use of derris dust has, however, apparently solved the residue problem on the tomato fruit and at the same time given excellent control of the tomato horn worm.

During the past several years derris dusts have been studied on many other insects where no arsenical residue problem is present. Among the insects that may be controlled are striped and spotted cucumber beetles, asparagus beetle, Colorado potato beetle, flea beetles in plant beds and on newly set out plants in the field and the squash vine borer.

Of all the insects that have been tested the only one which decidedly does not respond to derris is the corn ear worm. For several years celery in New Jersey has been badly infested with this insect. All attempts to control it with arsenical substitutes have met with failure. The corn ear worm is able to withstand large dosages of derris when taken internally. The caterpillar may be rolled in ground derris and yet be apparently unhurt. This lack of response is, however, apparently due to

the failure of the derris extract to get into the caterpillar's tissues because this caterpillar yields to derris extract hypodermically applied.

A SUMMARY OF STUDIES ON ARSENICAL SUBSTITUTES FOR CABBAGE WORM CONTROL ON CABBAGE AND LIMITATIONS ON ARSENICAL TREATMENTS

By W. H. WHITE, *Principal Entomologist, Division of Truck Crop and Garden Insect Investigations, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture*

ARSENICAL SUBSTITUTES

During the last three years intensive experiments have been conducted at the field laboratories of the Bureau of Entomology and Plant Quarantine at Chadbourn, N. C., Charleston, S. C., Baton Rouge, La., and Columbus, Ohio, with the objective of determining satisfactory substitutes for arsenicals in controlling the common species of cabbage worms on cabbage. The principal species concerned were the imported cabbage worm (*Ascia rapae* L.), the cabbage looper (*Autographa brassicae* Riley), the diamond-back moth (*Plutella maculipennis* Curtis), and the cabbage webworm (*Hellula undalis* Fab.).

In summarizing the results obtained in these experiments it may be stated that in general the nonarsenical compounds derris and pyrethrum have been more effective than paris green, calcium arsenate, or cryolite (natural or synthetic), and the treatment costs of these nonarsenicals have not greatly exceeded those of the arsenicals or the fluorine compounds. Lead arsenate was not included in these tests owing to the double residue hazard caused by its lead content and arsenic content.

As a general insecticide for the control of mixed populations of the four species of cabbage worms involved in the experiments, derris gave the best results and pyrethrum came next in effectiveness. In comparison, paris green, cryolite, and calcium arsenate were approximately equal in effectiveness, but in general they were inferior to either derris or pyrethrum.

Based upon the comparative efficiency, at economical strengths, of each of the insecticides tested against each of the principal species of cabbage worms present, the experiments indicated (1) that as a control for the imported cabbage worm derris was more effective than pyrethrum, paris green, cryolite, or calcium arsenate, while pyrethrum was superior to the last three materials; (2) that derris and pyrethrum were approximately equal in effectiveness in controlling the cabbage looper, and either material was more effective than paris green, cryolite, or calcium arsenate; (3) that derris and calcium arsenate were approximately equal in effectiveness in controlling the larvae of the diamond-back moth, while pyrethrum, cryolite, and paris green were comparatively less effective for this species; and (4) that in the instance of the cabbage webworm the comparative effectiveness of the five insecticides was not determined definitely.

In general, better results were obtained with dust mixtures than with sprays in the series of experiments reported upon in this summary.

The dusts were applied with rotary-type hand dusters in such a manner as to cover thoroughly all infested portions of the plants, care being taken to reach the insects with the dust whenever possible. The rate of application varied, from 15 to 20 pounds per acre being used per application, according to the size of the plants. Applications were begun when the worms first appeared on the plants and were repeated as often as was necessary to protect the crop. Usually three applications were made per crop.

DERRIS DUST.—Derris dusts, either home-mixed or commercial, containing from 0.5 to 1.0 per cent of rotenone, gave the most satisfactory results of any of the insecticides tested, in four sections of the Central, Eastern, and Southern States. Several nonalkaline materials, including finely-ground tobacco dust, finely pulverized clay, talc, diatomaceous earth, infusorial earth, and sulfur, proved satisfactory as diluents. Some of these diluents have the advantage of being more economical in cost and more readily available in some sections of the country than in others.

PYRETHRUM DUSTS.—Pure, fresh pyrethrum dust, containing approximately 0.9 per cent total pyrethrins, mixed with 5 parts (by weight) of the same diluents mentioned for use with derris, gave satisfactory results. This dust mixture gave best results when applied late in the afternoon or early in the evening.

PARIS GREEN DUSTS.—Results indicated that for cabbage worm control paris green was more effective in the dust form than as a spray, when used at a dilution of 1 pound of the paris green to 9 pounds of hydrated lime. It was indicated that applications may be made at the rate of 20 pounds per acre per application until the plant begins to form a head, provided the headed cabbage is stripped to four loose outer leaves when being prepared for market. If the marketed product is to bear a greater number of loose outer leaves than those allowed in the above grade, paris green or other poisonous insecticides should not be used at any time, on account of the harmful residue hazard involved.

CRYOLITE DUSTS.—Natural cryolite and synthetic cryolite gave favorable results when mixed with from 1 to 3 parts (by weight) of the same diluents as used for derris. The same care should be exercised to avoid harmful residue from cryolite as for arsenicals.

CALCIUM ARSENATE DUSTS.—Results with calcium arsenate showed a variation in the toxicity of various brands of this arsenical. When used in the undiluted form, applied at the rate of 15 to 20 pounds per acre per application, a well-known brand of calcium arsenate gave fairly satisfactory results. On account of the harmful residue hazard this material is subject to the same limitations as to time of treatments as paris green and cryolite.

Although, in general, dusts gave better results than sprays in the experiments under discussion, the following nonarsenical sprays gave promising results:

DERRIS SPRAYS.—Good control was obtained with a spray consisting of a derris-root-powder suspension in water diluted in such a manner as

to give a rotenone content ranging from 0.02 to 0.025 per cent in the spray—for example, 2 to 2½ pounds of derris-root powder containing 4 per cent rotenone per 50 gallons of water. Under some conditions it was found necessary to add to the spray a nonalkaline spreader or sticker such as high-grade liquid or powdered soap, miscible pine oil, or one of the sulphonated oils.

PYRETHRUM SPRAYS.—Fairly satisfactory results were obtained with commercial pyrethrum extracts, or pyrethrum-derris extracts in combination, diluted in accordance with the directions given by the manufacturer.

LIMITATIONS ON ARSENICAL TREATMENTS

The experiments with arsenicals had for their objective the determination of the limitations on arsenical treatments, and possible methods of applying insecticides containing arsenicals to cabbage in such a manner as to eliminate harmful residues on the marketed product. These experiments were performed during the two winter cabbage-growing seasons of 1932–33 and 1933–34 at the field laboratories of the Bureau located at Charleston, S. C., and Baton Rouge, La. Both spring and fall crops of cabbage were treated.

The results from observation on the growth of the plant and from chemical analysis of the treated cabbage are summarized as follows:

(1) In the instance of cabbage marketed as U. S. Grade No. 1, ordinarily bearing four loose outer leaves, insecticides leaving harmful residues can not be applied safely within a period of 40 days prior to harvest, or after the plant begins to form a head.

(2) In the instance of cabbage marketed as U. S. Grade No. 1 (Green), ordinarily marketed without any stripping of outside leaves or with more than four loose outer leaves, it was determined that arsenical insecticides can not be used at any time, owing to the danger of excessive residue on the marketed product.

(3) In general, these tests demonstrated that none of the insecticides harmful to man should be applied to any portion of the plant which is to be used as food.

(4) The amount of rainfall during the growth of the plants under observation evidently influenced the quantity of residue that remained on the plants at harvest, but apparently did not greatly affect the length of the period before harvest during which the insecticides could be applied safely without danger of harmful residues remaining on the market product.

THE CODLING MOTH SITUATION IN PENNSYLVANIA

By H. E. HODGKISS, *State College, Pa.*

A discussion of our codling moth program will be of small value without some brief statement relative to the general situation in Pennsylvania showing the more important practices that we are following in an attempt to secure commercial codling moth suppression.

The codling moth program in Pennsylvania is in fact two programs. The one is for 50 counties, the other is for the heavily infested area comprising four counties or parts of them. In the area of normal infestation the control problem is one of proper timing of the cover sprays and the use of proper methods in making the applications. The petal fall and four cover sprays are used in this area. The last cover spray in early July is primarily for the control of apple maggot in most of the northern and western counties. In Erie County and in the southeastern group it is essential to keep codling moth from becoming an outstanding problem. Except in an occasional orchard this entire area is not seriously infested and supplementary practices at present appear to be unnecessary.

In the four counties where the codling moth has gotton out of hand the suppression program is more intensive. Complete scraping and banding of trees is recommended. Treated bands are preferred although some growers who have the time and men use the burlap bands. This latter type, however, is being rapidly discarded. The common beta-naphthol double dipped band is recommended. There has been local interest in home-dipped bands, but this has not been urged since a local agency prepares them and last year met the price to counteract the effect of local dipping demonstrations we conducted. Other accessory measures such as the closing of storage buildings and screening the larger openings, and the removal of wood piles or cleaning up refuse are suggested. Screening and cleanup practices are seldom followed by the growers.

The spraying program comprises the petal fall and five or six cover sprays. The cover sprays other than four are designated as special sprays and are chiefly for use in the most heavily infested orchards, although no sharp differentiation is made in the spray letters. The spray program is aimed to control first brood larvae and the early hatch of the second brood.

Timing of the cover sprays is by means of bait pail catches of adults. Twelve stations were conducted during 1934 in nine counties. In previous years we used jars or vials containing larvae as a means of detecting emergence. For two years we used in addition to jars the bait pail records of the Experiment Station in Adams County.

The timing of the sprays must coincide with the requirements for disease control and mutual agreements have to be arrived at with the plant pathologists. There is a limit to the efforts that fruit growers will make in following suppressive practices, and that also must be taken into consideration. For that reason the actual spraying dates have not always coincided with the ideal periods as indicated by the flight records.

Flight records were kept in each of the counties in the heavily infested area and from these we arranged the control operations. The first peak of emergence occurred May 20 and coincided with the cluster apple period on May 23. A second peak came between May 28 and May 30 with the spray being applied June 9. The next cover spray was June 19, although the flights were not large. A special cover was applied on July 3 and the fourth cover was put on July 10, and a special letter of information was sent out August 8.

Three pounds of lead arsenate were used in all the cover sprays. Nicotine sulphate was included in the cluster apple or first cover primarily for red bug and apple leaf hopper, and in the third for codling moth. Lime sulphur solution was the fungicide and powdered skim milk was recommended in all cover sprays as the spreader and modifier of the spray. These combinations were state-wide recommendations.

Our spraying information operated in 54 counties with a total of 6,645 apple growers, 1,844 peach growers, 292 cherry growers and 504 grape growers or in a total of 9,285 plantings. This required us to prepare 550 letters of information for the county agents who in turn forwarded these letters to their growers.

State-wide statistics show that the percentage of the growers who applied the sprays in 1931 was as follows: Delayed dormant 88.0, Pre-Pink 89.7, Pink 91.2, Petal Fall 96.2, first cover 89.5, second cover 78.5, third cover 64.3, fourth cover 45.0. In 1934 these were: Delayed dormant 95.0, Pre-Pink 89.2, Pink 94.0, Petal Fall 99.0, first cover 97.0, second cover 82.3, third cover 68.7, fourth cover 52.7.

The response in the commercial apple growing counties was much better and in the 13 so classified the percentages of growers following the information was: Delayed Dormant 100.0, Pre-Pink 92.1, Pink 95.6, Petal Fall 99.1, first cover 99.1, second cover 93.8, third cover 86.6, fourth cover 58.8.

In Adams County which rates as the first in apple production 58.3 per cent of the orchardists applied all the sprays, which was an increase of 19.4 per cent over 1933. In Franklin County our number two in production 54.5 per cent applied all the sprays which was an increase of 14.5 per cent over 1933.

In Adams County 95.8 per cent of the growers applied all sprays up to the fourth cover, and in Franklin County 94.7 per cent of the orchardists followed the same practice.

In the heavily infested codling moth area comprising four counties 667 apple growers requested and received spraying information letters and in addition 522 of them asked and got personal attention during the year. These men have orchards ranging from 10 to 300 acres which are either in solid blocks or in separate plantings. The most of the orchards are in the larger category. There were 345 of these men who followed the recommendations exactly and 35 others who followed them through to the last cover spray. Two extensive orchardists applied either 6 or 7 covers. The average codling moth injury in well sprayed orchards was 3.1 per cent and in poorly or incompletely sprayed was 15.0 per cent.

Our experience with spray residue in 1933 indicated that with the three pound dosage of lead arsenate in all cover sprays apples would need to be washed. At harvest this year 155 samples of apples were taken for analysis of the residues. The analyses for arsenic when compiled showed that 111 were below the tolerance, 7 equaled the tolerance, and 37 were above the tolerance. Residual lead analyses showed 101 below the tolerance, 3 equaled the tolerance, and 51 samples were above the tolerance. Six of these samples were from our demonstration

blocks and four were from orchards having either six or seven cover sprays.

The results of the use by growers of our codling moth control program show that in four of the more extensive orchards, where the codling moth damage to apples ranged between 44 and 86 per cent in 1933, the total codling moth injury this year was reduced to either 4.7 per cent, 14.8 per cent, 21.0 per cent or 64 per cent.

From a state-wide angle yields in 171 completely sprayed orchards in 53 counties amounted to 1,539,600 bushels of which 37,874 bushels or 2.5 per cent showed stings or worms from codling moth. In 1933 these same counties had an average loss of 3.2 per cent of the apples. This year in 132 partly or poorly sprayed orchards in the counties above mentioned there were 952,410 bushels of apples harvested of which 159,536 bushels or 16.8 per cent were damaged by codling moth. The average loss for all the orchards from codling moth amounted to 10.5 per cent.

Timing and method of application are paramount considerations in any scheme of control. The relation of method of spraying to residual arsenic and lead was brought out rather clearly when these factors were compared. The differences in average percentages of control were wide, but the averages of the residual arsenic and lead analyses were not much different.

Substitutes for lead arsenate as a rule have not been entirely satisfactory. The oil-nicotine spray is probably the one best suited for our use in the late July or early August covers if we can arrange to use some substitute fungicide in the early July cover spray. With our heavy lime sulphur applications these late sprays follow too closely to permit of the use of oil in the late applications.

From our standpoint as well as that of our growers it appears that efforts placed on developing an entirely new arsenical product would result in a more general following of the recommendations than there is at present. Fruit growers as a whole can not be expected to recognize the necessity of changing fungicides or using substitute insecticides to avoid tolerance limitations. They will not do it.

There is need for a spreader different from casein which we have found to be well suited for control, but it makes removal of residues by washing too difficult.

PRESENT STATUS OF CODLING MOTH CONTROL IN OHIO

By T. H. PARKS, *Columbus, Ohio*

With the exception of two areas in opposite ends of the state, codling moth is being controlled satisfactorily with three cover sprays. These are being applied approximately three, five and nine weeks after the petal fall spray. Three pounds of arsenate of lead per hundred gallons and five pounds of hydrated lime are being used with lime-sulfur as a fungicide. This program has not led to a residue problem. While there was an increase in the number of stung apples in these orchards during the ex-

tremely hot, dry season of 1934, there is not an alarming codling moth situation and the problem is well in hand.

The localities where the codling moth situation is serious are: Ottawa County at the west end of Lake Erie and Lawrence County, southern Ohio. In Ottawa County there are many old orchards poorly sprayed for lack of proper equipment. In Lawrence County a scarcity of water supply in most seasons prevents the application of a complete schedule of sprays. The spray program followed by most growers in those areas is: petal fall, followed by two or three cover sprays against the first brood and one or two cover sprays against the second brood. This has not controlled the insect, which made serious inroads on the fruit in 1934. Wormy and stung fruit average from 10 to 40 per cent in Ottawa County, to as high as 60 per cent in Lawrence County, Southern Ohio. In the latter county, one grower, who applied seven well timed cover sprays in an efficient manner, had over half of his apples blemished to the extent of being culls. He insists that arsenate of lead will not control. Other growers experienced their worst year for worm blemished apples. Most of these injuries were caused by third generation larvae that appeared late in the summer. In Ottawa County, orchards which had clean fruit on August 10, suffered from late entering worms which came in the middle of August and continued up until early October. The worst injury came in orchards bearing a full crop of codling moths and a light crop of fruit. It is doubtful if seven cover sprays would have controlled under those conditions. There are no washing machines in that county. Until 1934 the losses from codling moth were not so severe; although the insect has been increasing since 1930.

Tree banding is fast gaining favor, but even banded orchards have required an increasing number of sprays to control. We have examples in northern Ohio of banded orchards that have required six cover sprays of arsenate of lead to secure control. These applications leave the fruit carrying a heavy residue.

The present situation is about as follows:

About 80 per cent of our growers are controlling codling moth easily with not more than three cover sprays.

About 10 per cent more could control it by applying another cover spray against the first brood without incurring a residue problem.

About 10 per cent need to apply later sprays than they are now applying and then wash their fruit to remove the residue. Few of these growers are able or willing to install washers at present. For these growers we shall advocate a more complete spray schedule with the choice of installing washing equipment, or applying substitute sprays against the second brood.

CODLING MOTH CONTROL PROGRAM IN THE SHENANDOAH-CUMBERLAND FRUIT REGION

By W. S. HOUGH, *Winchester, Va.*

1. Sprays and supplementary measures recommended.

The calyx and three cover sprays of lead arsenate (3 lbs. – 100 gal.) recommended for all orchards. Two and three cover sprays are advised for control of second brood larvae in heavily infested orchards only.

Scraping and banding the trees recommended in all heavily infested orchards. Packing house sanitation also advised but rarely is anything done along this line.

2. Proportion of growers following recommendations. It is estimated that 90% of the commercial growers follow the recommendations for spraying. Banding is rapidly on the increase.

3. Control obtained.

All degrees of control are obtained.

4. Outstanding disadvantages of the program.

(a) The value of banding is being reduced by the use of poles to prop heavily fruited limbs. Many larvae crawl down the poles instead of migrating to the tree trunks. The poles are then stacked at convenient places at the close of the picking season and serve as centers of infestation next year.

(b) The spray program assumes that growers have modern equipment sufficient to apply the sprays within the time advised.

(c) Growers do not readily understand why one orchard should receive more sprays than another in the same community. A number of factors contribute to this situation. Old trees afford many more hiding places for the mature larvae and thus there usually results a larger wintering population of larvae in older orchards than in younger orchards. Difficulty of control increases with the age of the orchard and the height of the trees. Difficulty of control also increases with the concentration of orchards in a given community, because orchard centers afford a greater and more regular supply of fruit from year to year. Irregular bearing of small isolated orchards greatly simplifies the problem of control. Consequently, one grower may produce cleaner fruit with only three sprays than another grower in the same region, but less favorably situated, can produce with double the number of sprays.

(d) Where alternate spray schedules are advised there is a tendency to follow the lighter schedule, especially is this true when financial matters are pressing or the market outlook is not favorable.

ARSENICAL SUBSTITUTES FOR CONTROLLING VEGETABLE INSECTS[1]

By J. N. RONEY and F. L. THOMAS, *Texas Agricultural Experiment Station, College Station, Texas*

During the past three years the investigation of insecticides that are harmless to humans, but poisonous or repellent to insects, have constituted one of the most important problems of entomologists, dealing with fruit and truck crops throughout the United States.

In Texas, work is being carried on by the Texas Agricultural Experiment Station in three different sections; namely, in the area served by the Plant Lice Laboratory in Galveston County, the Lower Rio Grande Valley Substation at Weslaco, and at the Winter Garden Substation near Crystal City. The greatest progress to date has been in connection with the control of worms on cabbage, the tomato fruit worm, and with the insect pests of snap or string beans. This paper deals particularly with the work that has been conducted from the Plant Lice Laboratory in Galveston County in controlling the cabbage worms—*Pieris rapae*, *Autographa brassicae*, and *Plutella maculipennis*—and the tomato fruit worm, *Heliothis obsoleta*.

The application of arsenical or fluosilicate insecticides is not recommended for any of the vegetable crops above named after the fruit or consumable portions begin to develop noticeably.

The materials tested have been finely ground dusts of sulphur, derris, and pyrethrum, or combinations of these. Sulphur is one of the natural resources of Texas, but the present supplies of derris and pyrethrum are imported. The insecticidal value of derris depends on its content of rotenone and related compounds, usually given in percentage of rotenone, while the insecticidal value of pyrethrum is in proportion to the pyrethrins it contains. The fresh powdered roots of derris and cubé, two commercial sources of rotenone-bearing dusts contain usually from 4 to 6 per cent rotenone. The ground up flowers of pyrethrum when fresh contain about .9 to 1.00 per cent pyrethrins.

Both derris and pyrethrum, when used as insecticides, are greatly diluted, but they are not recommended to be mixed with hydrated lime or other alkaline dusts unless they are applied immediately. Otherwise, the choice of a carrier, according to our preliminary experiments, may be based on the most convenient and economical dust that can be obtained in finely ground form. We have used 300-mesh sulphur, a finely ground clay, and Fullers' Earth.

The experiments for controlling cabbage worms and tomato worms were conducted last spring from April 21 to the latter part of June. During this period the minimum temperature was 50 degrees F., and average temperatures were above 70 degrees F. Since we have not analyzed experiments conducted when temperatures were colder, the results given herewith should be considered as preliminary.

Remarkable control was obtained for periods of one to three weeks under these conditions. However, emphasis is placed upon the necessity

[1]Read at meetings of Texas Ent. Society, San Antonio, Jan. 24–25, 1935.

TABLE 1. SHOWING THE PERCENTAGE OF CORRECTED CONTROL SECURED WITH THE VARIOUS DUSTS FOLLOWING EACH APPLICATION AND THE RELATION OF CONTROL TO CLIMATIC CONDITIONS IN SOUTHEAST TEXAS, 1934

Cabbage Worms

Period 1934	Mean temperature			Rainfall		Clear day		Interval between applications	Number observations or records	Corrected percentage of control				
	Maximum	Minimum	Mean	Amount inches	Number	Number	Per cent			Sulphur 300	Derris 10 Sulphur 90	Derris 10 Powco A 15 Sulphur 75	Powco A 25 Sulphur 75	Derris 10 Powco A 15 Fuller's Earth 75
5/2c 5/17.....	84.8	65.1	74.9	3.28	5	?	?	16	1	None	—	39.6	—	—
5/18c 5/24.....	87.8	63.0	75.4	0.00	0	?	?	7	1	None	—	36.1	—	—
4/21b5/11.....	82.9	62.7	72.8	0.96	3	6	28.6	21	3	41.7	98.1	99.1	99.8	99.2
5/12b5/27.....	86.2	62.7	74.4	0.98	3	8	50.0	16	3	22.4	97.1	98.9	98.2	98.9
5/28b6/4.....	88.2	64.1	76.1	0.08	1	4	50.0	8	1	98.9	98.3	99.7	99.9	99.6
6/7a6/18.....	94.7	72.4	83.5	0.00	0	9	75.0	12	3	—	93.0	94.0	94.3	—
6/21a7/3.....	93.4	71.1	82.2	0.21	1	6	46.1	13	3	—	99.3	98.3	99.7	—
Tomato Fruitworms, *Heliothis obsoleta*														
5/2–5/17.....	84.8	65.1	74.9	0.83	4	2	12.5	16	1	18.8	60.0	41.2	62.4	44.7*
5/18–6/5.....	87.9	64.3	76.1	0.91	3	10	52.6	19	2	21.7	28.1	76.9	22.6	51.9*
Average per cent control of 5 cases in which all are comparable.....										40.7	76.5	83.2	76.6	—

*Bordeaux arsenic lead.

for beginning the applications as soon as the worms appear if the best results are desired, as the worms usually increase in numbers very rapidly after the infestation begins. Two to three applications proved sufficient to protect each of three cabbage crops.

A dust containing 10 per cent derris or .5 per cent rotenone and 90 per cent 300-mesh conditioned sulphur possessed in greater degree those qualities of effectiveness and economy than any other dust or combination used for controlling cabbage worms.

Although yield is not the only criterion used in determining the worth of the insecticide, it is interesting to note that the increased yields in two experiments in which this dust was used were a little less than 2500 and 8000 pounds per acre of marketable cabbage. The derris-sulphur dust which produced this yield should not cost more than 10 cents per pound ready to apply and should be used at the rate of 20 to 25 pounds per acre per application with the aid of suitable dusting machinery.

Three hundred mesh, conditioned sulphur alone produced increases in yields in all the experiments where it was tested. These increases varied from a little less than 400 pounds to 2700 pounds per acre. The latter was in the same experiment where the derris-sulphur dust produced an increase of approximately 8000 pounds per acre.

Derris is slower than pyrethrum in its reaction on insects and little benefit can be seen within 48 hours following an application. Our experiments indicate also that pyrethrum is limited more than derris in regard to its usefulness in dry or irrigated areas.

Table 1 shows the percentage of corrected control secured with the various dusts following each application, and the relation of control to climatic conditions.

Table 2 shows the yields and increase in yields on the treated plats.

Table 3 contains information regarding the cost of the insecticides used.

TABLE 2. GAIN IN YIELDS IN POUNDS PER ACRE OF THE TREATED AS COMPARED WITH THE ACTUAL YIELDS OF THE UNTREATED PLATS IN ONE TOMATO AND THREE CABBAGE EXPERIMENTS

Experiment number	Conditioned sulphur 300	Derris 10 Sulphur 90	Derris 10 Powco A 15 Sulphur 75	Powco A 25 Sulphur 75	Derris 10 Powco A 15 Fuller's Earth 75	Bordeaux 4–4–50 Arsenic lead 2 lbs.	Checks (untreated)
Cabbage							
C.....	377	——	1,575	——	——	——	2,958
B.....	2,730	7,980	9,465	9,750	8,739	——	270
A.....	——	2,480	4,602	3,342	——	——	975
Tomatoes....	2,015	*	5,124	*	——	4,919	*

*Yields on these plats were not comparable as each was staked and pruned differently, while the others were neither staked nor pruned.

TABLE 3. PERCENTAGE OF ROTENONE AND PYRETHRINS IN THE DUSTS USED AND COST OF MATERIALS AND MIXTURES

	Percentage used	Rotenone content	Pyrethrins content	Cost per pound	Cost of materials	Cost per pound of dust
Derris.....	10	.5%	——	.72	7.20	.10½
Sulphur....	90	——	——	.03½	3.15	——
Powco A...	25	——	.125%	.35	8.75	.11½
Sulphur....	75	——	——	.03½	2.62	——
Derris.....	10	.5%	——	.72	7.20	——
Powco A....	15	——	.075%	.35	5.25	.15
Sulphur....	75	——	——	.03½	2.62	——

ARSENICAL SUBSTITUTES FOR CONTROLLING CERTAIN VEGETABLE INSECTS[1]

By J. N. Roney and F. L. Thomas, *Texas Agricultural Experiment Station, College Station, Texas*

This paper contains the results of two years of experiments on the control of two important insect pests of snap or string beans, viz., the belted cucumber beetle, *Diabrotica balteata*, and the bean leaf hopper, *Empoasca fabae*.

The belted cucumber beetle is a pest that has grown to considerable importance throughout the coastal and South Texas areas. It feeds on the blooms and foliage, causing the former to shed and thereby directly reduces the yield; the larva causes injury by feeding on the roots of the plants. The occurrence of this insect practically coincides with that of the bean leaf hopper, the more important of the two. Together these insects are the most important limiting factor to the production of fall beans in the southern part of Texas. Although the beetle feeds by chewing and the hopper by sucking its food, both fortunately may be controlled by means of the same application, which in one sense may be considered as an arsenical substitute.

In these experiments several types of sulphurs and pyrethrum-sulphur mixtures were used; also a copper-lime dust. Each proved effective in controlling the insects and were profitable on the basis of the increased yields which were obtained. On the whole, it is easier to control the bean leaf hopper than the Diabrotica. It is difficult to say which of the insecticides used gave the best control, as the differences in some cases are not significant. A pure sulphur gave better control than a conditioned sulphur of the same degree of fineness, but there was very little difference between a pure, 200-mesh sulphur and a conditioned, 300-mesh sulphur as far as control is concerned. As a general rule, the physical quality of the pure, finely ground sulphurs, however, is rather poor for dusting purposes. The conditioned sulphur which was used contained about two and one-half per cent of magnesium carbonate to improve it for dusting purposes.

There was very little difference between the results secured with the 300-mesh conditioned sulphurs and those obtained on the plat when a 20–80 copper-lime dust was used.

In nearly all cases the pyrethrum-sulphur mixtures were slightly better than the sulphurs alone, but the margin of differences does not justify the extra cost sufficiently to bring about their recommendation. The percentages of control obtained with the various pyrethrum-sulphur mixtures does not correspond to the proportions of pyrethrins which they contain, according to the manufacturer, and it appears as though other factors must be present to produce these variations.

The present recommendations for control of the bean leaf hopper and the belted cucumber beetle on snap beans consists of two to three applications of a 300-mesh conditioned sulphur applied at the rate of 20 to 25

[1]Contribution No. 687. Read at Texas Ent. Society Meetings, Jan. 24–25, 1935.

TABLE 1. SHOWING THE PERCENTAGE OF CORRECTED CONTROL SECURED WITH THE VARIOUS DUSTS FOLLOWING EACH APPLICATION, AND THE RELATION OF CONTROL TO CLIMATIC CONDITIONS, 1933 AND 1934

Empoasca fabae

Period	Mean temperature			Rainfall		Clear days		Interval between applications	Number of observations or records	Corrected percentage of control								
	Max.	Min.	Mean	Amt. ins.	Number days	Number	Per cent			Sulphur 300 Spider	Special 300	Sulphur 200 Rust	Sulphur 200 Owl	Copper lime 20–80	Powco A 15 Sulphur 85 300	Powco A 25 Sulphur 85 300	Powco D 35 Sulphur 65 300	Powco C 25 Sulphur 75 300
1933																		
10/10–10/18	86.4	64.0	751.1	0	0	2	22.2	9	3	95.3	83.9	75.0	84.6	—	85.1	86.3	92.7	—
10/19–10/31	81.5	62.5	722	1.07	4	5	36.9	13	2	71.9	66.8	40.1	100	—	71.8	87.9	67.8	—
1934																—		
10/26–11/6	81.9	58.8	703.7	.61	2	5	41.7	12	2	87.8	—	—	—	82.6	94.1	—	—	94.9
11/7 –11/22	77.4	57.7	675.3	2.64	4	2	12.5	16	3	90.0	—	—	—	88.7	91.0		—	91.0

Diabrotica balteata

1933																		
10/10–10/18	86.4	64.0	751.1	0	0	2	22.2	9	3	71.3	83.2	73.6	78.2	—	72.1	59.3	79.6	—
10/19–11/8	81.5	62.5	722	1.07	4	5	36.9	21	4	73.7	74.1	49.8	74.1	—	68.4	83.5	73.7	—
1934																		
10/26–11/6	81.9	58.8	703.7	.61	2	5	41.7	12	2	85.2	—	—	—	79.8	79.8	—	—	81.8
11/7 –11/22	77.4	57.7	675.3	2.64	4	2	12.5	16	3	84.7	—	—	—	81.5	92.3	—	—	86.7
										—	—	—	—	—	—	—	—	—
1933 average										78.0	77.0	59.4	84.2	—	74.3	79.2	78.4	—
1934 average										85.3	—	—	—	83.1	89.3	—	—	88.6

7 days interval

pounds per acre. This dust has produced as high as 30 bushels, or 50 per cent increase in yield per acre.

MOSQUITO CONTROL WORK OF TODAY

By F. C. Bishopp, *Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture*

Mosquitoes are among man's most dangerous and omnipresent foes. That they play an important role in the transmission of disease is generally recognized, and I have no doubt that if the full economic significance of the group were appreciated by entomologists, the number of our profession engaged in the work of controlling mosquitoes would be multiplied many fold.

Economic Importance.—The heavy toll of human lives taken by malaria is abundant reason for claiming the attention of the best scientific and engineering ability of the world, and the support of the entire population for sound control programs directed against anopheline mosquitoes. The death loss from malaria, although high in many parts of the world, even including some localities in our own country, is not really the most important consideration. What is of greater economic significance is the lowered vitality and efficiency of a large percentage of the people who live in malarial sections. You will recall that Dr. L. O. Howard has estimated the annual loss from malaria in the United States at $100,000,000.

Although yellow fever has been encouragingly reduced by the strict quarantines and as a result of repressive measures against mosquitoes, we still have ample reason to maintain an active interest in its suppression. We should keep in mind that the important transmitter, *Aedes aegypti*, is constantly present in considerable numbers throughout the Southern States, and that recent investigations have indicated that no less than 13 species of the same genus are capable of carrying this scourge of the human race. A rather recent investigation of yellow fever in tropical Africa appears to show that it is endemic there and may occur among natives in so mild a form as to be unrecognized. Furthermore, these investigations indicate that certain monkeys are susceptible to yellow fever, and these facts make the outlook for entirely eliminating the disease much less hopeful than was thought a few years ago. We should not lose sight of the fact that since the immune population here in the United States and in tropical America is rapidly diminishing, an introduction of the disease and its spread through the Americas would result in most dire consequences. Communication by airplane and other rapid methods of transportation between the tropics and our own country add greatly to the possibility of infected mosquitoes being brought to this country.

Dengue, or break-bone fever, while seldom fatal, is a painful and debilitating disease. An outbreak, such as swept the South a few years ago and was repeated on a smaller scale in certain southern cities during the past season, has a decidedly adverse economic effect and suggests the

need of more effective control measures against the yellow-fever mosquito which transmits the infective organism.

Filariasis of man is of only local occurrence in the United States, but it is a malady of distinct importance in tropical America, and its occurrence there certainly furnishes added argument for more effective mosquito control.

Among the animal diseases, the widely spread malady of chickens known as "fowl-pox" is readily transmitted by the common rain-barrel mosquito and certain other species, and the common southern filarid disease of dogs, heart worm, is carried exclusively by these insects.

Recent investigations by Dr. B. A. Kelser, of the U. S. Army, and others have shown that mosquitoes are capable of carrying the devastating horse disease known as encephalomyelitis. It seems reasonable to believe that this disease is transmitted exclusively by this group of insects and to surmise that its ultimate control may be closely tied up with the reduction of the mosquito population. The distribution of encephalomyelitis has been associated with an abundance of mosquitoes, as in the case of the recent outbreaks in the Central Atlantic States and in the irrigated districts of the West. Severe losses are suffered, since at times as high as 90 to 95 per cent of the horses in an infested district die of the disease.

In the United States a large part of our population is also concerned with the so-called "pest mosquitoes," that is, those species which have not been incriminated in disease transmission but which nevertheless cause great annoyance and discomfort by their bites. These mosquitoes, when in great numbers, adversely affect man in many ways, though it is often hard to weigh such effects in dollars and cents. Obviously, when the comfort and happiness of people are seriously interfered with the effects may be far-reaching. Loss of sleep by night-biting mosquitoes lowers efficiency and induces ill temper. Day-biting mosquitoes interfere with industrial activity, farming, lumbering, fishing, and especially the operation of summer resorts, resulting in retarded development and lowered tax valuation. The benefits from effective mosquito control are illustrated by the studies, by Mr. Robert F. Engle, president of the Ocean County (N. J.) Mosquito Extermination Association, of taxable values in parts of New Jersey. His analysis shows that the increase in taxable values during the 15-year period 1916 to 1930 in the area in New Jersey where mosquito control was carried out was $555,345,000 greater than where such work was not done.

While the most urgent demand for pest-mosquito control is likely to come from recreational sections, the effects of these pests on the general population and on farming operations, especially on livestock raising, is receiving more attention than formerly.

Relation of Mosquito Control to Other Economic and Social Problems.—There is an intimate relationship between land reclamation and mosquito control. Many of the most fertile parts of the country are poorly drained and therefore mosquitoes are likely to be produced in such areas in troublesome numbers. Naturally the value of such land for agricultural purposes induces drainage, and incidentally the mosquito

problem may be taken care of. It seems reasonable to conclude that the recession of malaria in the Northern States has been largely brought about by the extensive utilization of the land for agricultural purposes. The reclamation of arid lands, on the other hand, may bring about serious mosquito problems, both in the places where water is impounded for irrigation purposes and in the irrigated areas themselves. It would appear logical to give more consideration to the mosquito question in connection with the planning and carrying out of reclamation projects. Mosquitoes, and especially those which transmit malaria, may be serious handicaps during reclamation operations, in which case direct action against the mosquitoes should accompany or precede the reclamation.

Many reclamation projects involving drainage have been ill advised, and some of the ventures unsuccessful, and the losses attending these operations and the destruction of wild life have made many people think that extensive drainage looking toward mosquito control would be as unsatisfactory.

The impoundment of water in connection with power projects usually presents some serious mosquito problems. The importance of having plans for such developments carefully considered with reference to the prevention of mosquito breeding and the selection of town sites made with reference to avoidance of mosquito attack cannot be too strongly emphasized.

The present strong tendency to discontinue the farming of marginal lands makes it important to consider the relationship between mosquito breeding and the withdrawal of such lands from agricultural use. The value of these marginal lands is of course tied up with the question of the propagation and conservation of wild life and other natural resources as well as their use for recreational purposes.

Recently there has been expressed in many quarters a fear that extensive mosquito-control operations may seriously affect wild life, particularly water fowl. While most of the fears regarding this effect of mosquito control are unfounded, it is a subject that the entomologists and sanitarians charged with the responsibility of mosquito control should study carefully. Obviously it is impossible to leave nature absolutely in the raw without having trouble from mosquitoes. On the other hand, it appears impossible completely to control mosquito breeding over a given area without disturbing certain forms of animal or plant life. It is believed, however, that mosquito control may be carried out in areas where the density of human population demands such action, without adversely affecting the general status of wild life.

There is a need for a better understanding of the methods used in mosquito control on the part of those concerned with wild-life protection. A more complete knowledge of the wild-life problems in the areas affected would no doubt also aid those charged with the responsibility of mosquito control in proceeding along lines that would least affect such life. The feeling seems to be altogether too general that mosquito control means the elimination of water. This is not necessarily the case, for by the construction of dams or dykes serious mosquito-breeding areas may be changed to attractive clean-banked ponds or

lakes favorable to fish and water fowl but unfavorable to mosquitoes. The system of ditching for the control of salt-marsh mosquitoes does not contemplate the exclusion of tide waters over the areas but merely eliminates standing water, giving the tide free ebb and flow over the mosquito-producing marshes.

Fear has been expressed that mosquito-control work would adversely affect the muskrat industry. Preliminary inquiry into this question seems to indicate that this is not the case; in fact, in some areas muskrats have actually come in or increased in number since the ditching systems were installed.

The relationship between mosquito control and recreation has already been touched upon. With shorter working hours comes the need for ways of utilizing our leisure so that we may become a healthier, happier, more contented people. More leisure hours means more time for outdoor life, and thus the importance of mosquito control, both in the environs of our homes and in various recreational centers, is emphasized.

Certain problems of mosquito control are intimately tied up with the problems of stream pollution. House mosquitoes breed in myriads in sewage-polluted streams where the fish which serve as a natural controlling agent for mosquitoes cannot live.

More Research on Mosquito Problems Needed.—The mosquito-control procedure of today is essentially sound. There is no doubt, however, that further research will result in the development of more effective and more economical methods and will indicate more clearly the economic and social reasons for mosquito control. Important investigational work is going forward in many parts of the world under governmental auspices and in privately supported institutions. The investigating groups, however, have been unable to take up more than a few of the very important problems which are demanding solution.

It might be well to point out the fact that mosquitoes lend themselves admirably to research. Nearly all of our States have important mosquito problems, and many phases of them constitute interesting and worthwhile projects for investigation. The opportunity should not be lost to take up some of these as station projects or as research problems for graduate students. Much additional work should be done upon the question of insecticides for mosquito control. The value of mosquitoes as experimental insects for testing insecticides has well been demonstrated by the recent work of Dr. F. L. Campbell and his associates.

As might be expected, medical men have made most of the important contributions with reference to the relationship between mosquitoes and disease. Entomologists might well play a more important part in connection with such research work. There still remain a number of important fields in which investigational work of this character is needed, as for instance the study of the relationship between mosquitoes and such virus diseases of man and animals as encephalomyelitis.

The biologies of many of the mosquitoes are by no means well worked out, and extremely interesting and important ecological studies might well claim the attention of dozens of entomologists. The need for research work on the relationship between mosquito control and wild life has already been indicated.

CONTROL WORK.—The outstanding accomplishments of General Gorgas and his associates in controlling mosquitoes in Cuba and Panama are familiar to all. Since the initiation of that large-scale pioneer work, projects of even greater magnitude have been successfully carried on in many parts of the world. The Roman Campagna, long known as a hotbed of malaria, has been transformed into a productive agricultural region, and splendid work has been done in England, Holland, Germany, The Union of Soviet Republics, Spain, Italy, Greece, Palestine, India, Malaya, Dutch East Indies, The Philippines, Canada, and the United States.

On account of the health aspects of the mosquito problem, and the fact that these insects may fly considerable distances, control work is being recognized as a community, county, State, or Federal problem rather than an individual one. Undoubtedly the most effective way to organize such work is on the basis of larger civil units and under laws applicable to an entire State. Very effective mosquito-fighting organizations have been set up and are successfully functioning in a number of our States, notably Massachusetts, Connecticut, New York, New Jersey, Virginia, Florida, Illinois, Utah, and California. In addition considerable control work on malaria mosquitoes has been under way for a number of years in nearly all the Southern States.

While the economic depression has had the effect of curtailing regular appropriations for mosquito control in a number of the States in which this work has been going on for many years, the suitability of such work for relief employment has caused mosquito-control projects to be initiated in many new localities, and work already in progress in many others to be materially supplemented.

The approval, during the winter of 1933–34, as Federal projects under the Civil Works Administration, of the control work against the malaria and pest mosquitoes gave great impetus to the war on these pests. The malaria-control project was directed by the United States Public Health Service, with Dr. L. L. Williams, Jr., in charge. This project was so set up that funds for the supervisory work were provided by the Public Works Administration, thus giving the project a more permanent basis than was the case in the control project directed against the pest mosquitoes by the Bureau of Entomology and financed entirely under the Civil Works Administration.

The Federal malaria control project was started in December 1933 in 14 States. In the organization provided under the Federal funds were 14 assistant State directors, with 56 district supervisors, and 212 local supervisors. For nearly 4 months an average of 64,000 workers were employed. The maximum number of laborers at work during any week of this period was 120,000. Nearly 6,000 miles of ditch were dug, draining 100,000 acres of ponds, and more than 200,000 acres of swamp, affecting adjacent populations estimated to total 8,000,000. The Federal control project was materially supplemented in a number of States by local work relief. The C.W.A. malaria mosquito control project was terminated at the end of March 1934, but much of the malaria-control work was continued under the Emergency Relief Administration. At

this date Dr. Williams reports that nearly all of the sub-projects begun under the C.W.A. have been completed, and that most of the remainder will be finished by the end of 1934. This does not apply to a few very large sub-projects that have been undertaken on the theory that relief labor may be available for some time in the future. During the last 6 months of the emergency relief operations approximately 2,000 miles of additional ditch have been dug, draining over 16,000 acres of ponds and somewhat more than 30,000 acres of swamps. In places where drainage is not at present feasible, some house-screening projects have been undertaken.

The Federal pest mosquito control project under the Civil Works Administration was approved on November 28, 1933, and work was begun soon after in 32 States and the District of Columbia. Despite the extreme difficulty of obtaining tools and other equipment and the lack of surveys and of competent supervisors in many of the States, the work was gotten under way in a remarkably short time. By the end of December over 13,000 men were at work, and by the middle of the following January the number employed exceeded 20,000. The maximum number of laborers employed during any week was 21,389. In most instances the State entomologist or some other State official directly concerned with insect control was designated as the State director of the project. An assistant State director was then employed. His salary and those of the district and local supervisors and foremen, as well as those of the laborers, were paid from the funds of the Civil Works Administration.

While the greater part of the work was done in the Atlantic, Gulf, and Pacific Coast States, because of the importance of their mosquito-control problems, some beneficial results were also accomplished in a number of the inland States.

Material aid in the form of trained personnel was lent to the Bureau by those States that had been carrying on mosquito-control work for a number of years. This was particularly true of New Jersey, from which State a number of men were drawn to aid in planning and supervising in a general way the work in many other States.

In general the plan was to select sub-projects close to centers of population where unemployed men were available, and also where a large population would be benefited by the elimination of mosquitoes.

The type of work was much diversified. By far the greatest part of it was on the salt marshes, some of which were of the open-meadow type common to the northern salt-marsh areas, and some, as in Florida, of dense mangrove growth. In certain sections of the coastal area, especially where tidal action is limited, dikes were constructed and tide-gates installed. Much of this type of work was carried out in Georgia where the sand flies as well as salt-marsh mosquitoes are very serious pests. The work in Georgia consisted essentially of diking off narrow necks of salt marsh extending inland, installing tide gates to allow the water to drain off the land above the dikes during low tide and yet to protect it during high tide. This essentially changed the salt marsh above the dikes into fresh-water areas, and the ditching done above the tide gates prevented the formation of stagnant pools.

In some instances neglected drainage canals were freed of fallen timber and debris, stream banks were cleared and straightened, some fresh-water swamps and seepage areas were ditched, and many mosquito-breeding places along railways and highways were eliminated by ditching or filling. Many unsightly stagnant pools around city dumps were eliminated and the dumps themselves levelled off and covered.

The project was abruptly closed on February 15, 1934, leaving many operations incomplete. On the whole, however, the work accomplished during this short period was reasonably satisfactory, both as regards amount and quality. Over 1,930 miles of ditch were dug; about 400 miles of stream bank cleared, deepened, and straightened; and dikes to the extent of 53,020 feet were thrown up. A total of 7,566 feet of metal and concrete culverts were put in, and about half as much more were reset or repaired. About 50 tide gates were installed. In dredging, filling, and excavating, about 400,000 cubic yards of dirt and rock were moved. Brushy areas totaling approximately 7,600 acres were cleared, and approximately 4,000 feet of tile drains were installed.

During the past summer an effort has been made to check up as far as possible on the influence of this work on mosquito abundance. Many reports indicating decided improvement in mosquito conditions have been received, and in a good many localities the work appears to have largely solved the mosquito problem.

In addition to the value of these projects in putting unemployed men to work and the direct benefits in the reduction of mosquito abundance, a number of less tangible benefits were obtained. Two of these were the development of the interest of a large group of men in the betterment of health and living conditions in their communities and the training of a corps of entomologists and engineers who will be available in the future as various communities undertake local mosquito-control work. Furthermore, the demonstration of the methods of procedure and the beneficial results which may be derived from work of this type greatly stimulated interest and resulted in many cases in a continuation of the sub-projects. In many communities where this was impossible the desirability of continuation on local initiative when conditions should be more favorable was recognized.

PRESENT STATUS OF MOSQUITO CONTROL WORK IN THE UNITED STATES.—Upon the termination of the Federal project arrangements were made in many States to continue the work either as State or local projects. In fact wherever funds have been available the work has gone on. In New England good progress has been made in the States of Massachusetts, Rhode Island, and Connecticut. The latter State has been consistently and effectively reducing mosquito-breeding places during the past several years and at present the ditching over the 20,000 acres of salt marsh in that State is nearly completed.

In the Middle Atlantic States, as might be expected, New Jersey is leading in anti-mosquito work. A large percentage of the salt-marsh breeding ground in the northern half of the State has been ditched, and a great deal of upland work has been done. Effective work is also under way in New York City, on Long Island, and in Delaware. In Delaware

two Civilian Conservation Corps camps devoted to mosquito-control work have been established and are now active. Also research projects on the effect of mosquito ditching on wild life, especially with reference to the effect on waterfowl and muskrat raising, have been inaugurated.

Some of the C.W.A. projects in the Southern States were continued after the closing of the Federal project, and in several of these States extensive anti-malaria work has been carried on throughout the season. In a number of the interior States some good work has been accomplished. Utah in particular has gone on with large-scale control operations since the closing of the Federal project.

On the Pacific Coast, California has continued its effective drive against mosquitoes, and in Oregon and Washington, in several instances, the practicability of mosquito control has been decisively demonstrated.

PRELIMINARY REPORT ON THE FLUORINE COMPOUNDS AS INSECTICIDES

By Irene D. Dobrosky

The fluorine compounds had been used as insecticides in Europe for many years (1), but it was not until 1915, that they were first called to the attention of American entomologists, for the control of roaches. To this day, sodium fluoride is considered to be the best insecticide to use against roaches (2). For the control of certain insects the fluorine compounds have been found to be quite specific and far superior to other insecticides when used under the same conditions. Marcovitch and Anthony (3) have shown that housefly larvae breeding in manure can be readily controlled by sodium fluosilicate. Chamberlin (4) has shown that barium fluosilicate is extremely toxic to the tobacco flea beetle. Dietz and Zeisert (5) report very good control of the black and margined blister beetles with barium fluosilicate. Elmore (6) obtained excellent results with the fluorides against the pepper weevil. His best results were obtained with sodium fluoaluminate or synthetic cryolite, but, he said he would not recommend this material because of the injury it caused to the pepper plants.

This brings up the point that the name "cryolite" connotes a natural mineral, and therefore, should not be used to designate a manufactured article. Whenever these two materials are used, they should be specified as natural cryolite and synthetic cryolite. This distinction is necessary because the two materials differ in certain respects. Natural cryolite is soluble in water at the rate of 1 to 2800 parts, whereas synthetic cryolite, as reported by DeLong (7), is soluble at the rate of 1 to 1600 parts of water. There are several different brands of synthetic cryolites on the market and nine of them analyzed by Frere (8) differ in their chemical composition. The presence of the highly soluble compound, sodium fluoride, in varying amounts is another important difference. These factors account for the burning of foliage sometimes occuring from the use of synthetic cryolite. In none of our experiments this season with

natural cryolite on a wide variety of plants was any injury observed. Field and laboratory experiments have been carried on during the past season to determine which insects are specifically controlled by the fluorine compounds.

TOBACCO FLEA BEETLE EXPERIMENT.—An experiment for the control of tobacco insects by fluorine compounds was carried on by the Tobacco Substation in Lancaster County, Pa. The use of arsenical insecticides is

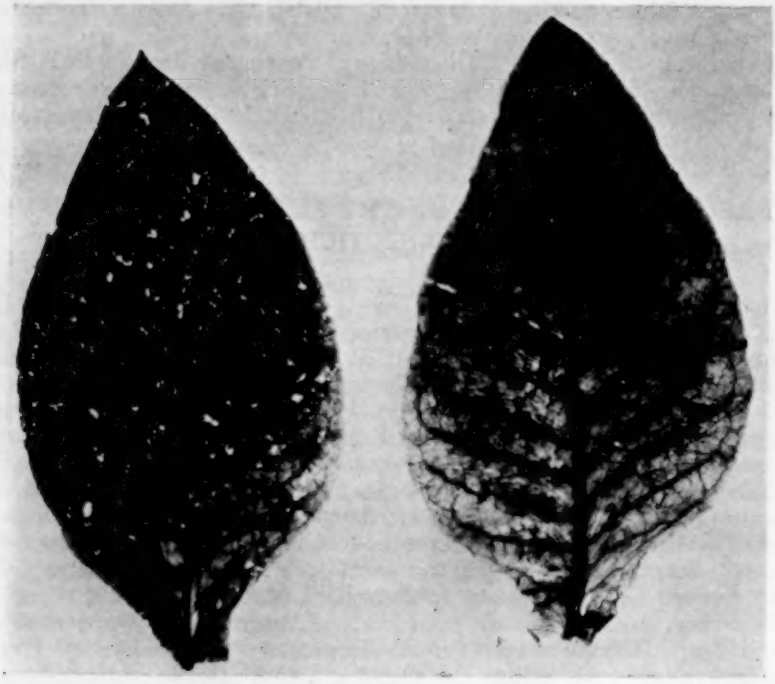

FIG. 85.—Two tobacco leaves. Right–Dusted with natural cryolite and talc. Left—Dusted with barium fluosilicate and copper-lime, and showing Flea Beetle Injury.

being discouraged because of the fact that arsenical compounds are decomposed in the burning of tobacco and can, therefore, be taken into the human system by inhaling the smoke.

The tobacco plants used in this experiment were grown in rows, half of which were dusted with barium fluosilicate, and the other half with natural cryolite. Four applications were made during June and July. The barium fluosilicate was used in combination with a copper-lime dust: the natural cryolite was used with talc at a 40–60% strength. As shown in Figure 85, control of the tobacco flea beetles, (*Epitrix parvula* Fabr. and *E. cucumeris* Harris), with barium fluosilicate was very poor, due entirely to the fact that lime was used with it. Fleming (10) and

Carter (9) have both stressed the fact that lime decreases the toxicity of the fluosilicates. As will be shown later in this paper, lime decreases the toxicity of cryolite also. It seems justified, therefore, to make the statement that lime should never be used with any of the fluorine insecticides. If lime instead of talc had been used with cryolite on the tobacco leaf in Figure 85, it would undoubtedly have presented the same appearance as did the leaf dusted with barium fluosilicate and copper-lime. Unfortunately no check plants were kept for comparison. The cryolite-talc mixture gave such good control that it may rightly be said to be specific for the tobacco flea beetles.

EGGPLANT FLEA BEETLE EXPERIMENT.—That the fluorine compounds are specific in the control of flea beetles, was again strikingly shown in another experiment with eggplants. A small experimental plot was planted to beans, tomatoes, cucumbers, cabbage and eggplant. This plot was surrounded by other vegetable gardens in which no effort was made to control the insect pests. There was present, therefore, a fairly heavy infestation of Mexican bean beetles, striped and spotted cucumber beetles, cabbage worms, eggplant flea beetles, and several other species of flea beetles. The plants were kept covered during their growing period by five applications of insecticides. Different strengths and combinations of the following insecticides were used: natural cryolite, synthetic cryolite, barium fluosilicate, magnesium arsenate, and derris dust. One-half of a row of eggplants was dusted with natural cryolite and talc, 40–60%; the other half was left untreated for a check. Figure 86 shows leaves taken from two plants growing about 10 feet apart. The leaf taken from the check plant shows the amount of damage the flea beetles caused. The leaf dusted with natural cryolite shows almost complete protection against the eggplant flea beetle, (*Epitrix fuscula* Crotch), and at least two other undetermined species of flea beetles which were seen feeding on the eggplants.

MEXICAN BEAN BEETLE EXPERIMENTS.—There were two varieties of beans grown in the above-mentioned plot, the green Bountiful and the Yellow Wax bean. It was noted that the Mexican bean beetle, (*Epilachna corrupta* Mul.) showed a decided preference for the Bountiful variety. This was later verified in a one-acre plot planted to these two varieties.

The Mexican bean beetle has become such a serious pest in New Jersey, that many farmers have given up growing beans. Special efforts were, therefore, directed against this insect both in laboratory and field tests. Marcovitch (11, 12, 13, 14) showed several years ago that the fluorine compounds were particularly effective against this beetle. In spite of his work, magnesium arsenate has been recommended for the past few years, but results have not come up to expectations.

FIELD EXPERIMENTS WITH THE MEXICAN BEAN BEETLE.—A field of beans over an acre in extent was laid out into 30 plots. Fourteen different treatments of sprays and dusts were made in duplicate. The whole field received two treatments, one at the time the bean plants had from three to four true leaves, and the second when the plants were in full bloom. By such timing, it was found that good control of the beetle was obtained in some of the plots, depending on the insecticide used. These insecti-

cides were natural cryolite, natural cryolite with a positive charge, synthetic cryolite, barium fluosilicate, derris dust, and magnesium arsenate. The dusts were used at the rate of 25 pounds per acre when the plants were small, and 30 to 35 pounds for the second application. Most of the materials were used at two strengths, 25–75% and 40–60%, with talc or lime as the diluent. The criterion used to estimate the amount of

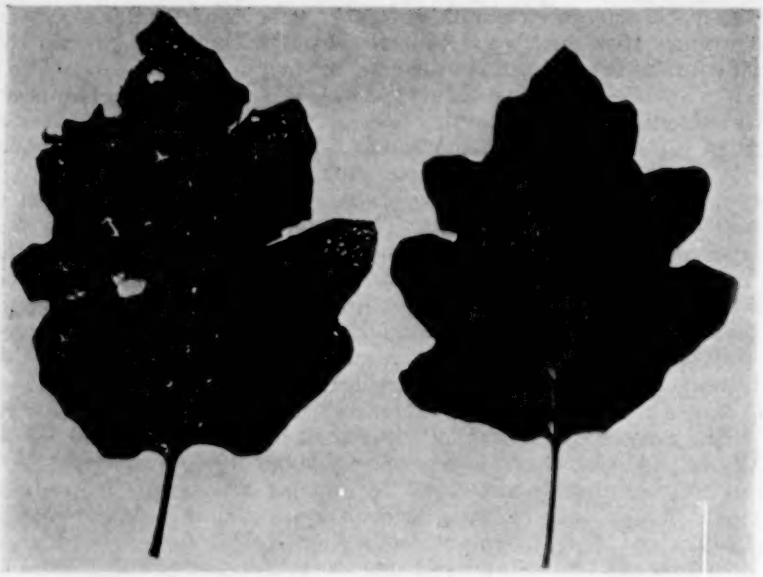

FIG. 86.—Two eggplant leaves. Right—Dusted with natural cryolite and talc. Left—Untreated check.

damage by the beetles was the percentage of beans showing the characteristic chewing scars of this beetle. As soon as the beans were ready for marketing the pods from the center rows were picked and counted. The percentage of chewed pods for each of the 30 test plots was obtained, and the plots were listed as to merit on this basis. The best results were obtained with the positive-charged natural cryolite used as a dust with talc at a strength of 40–60%. There were frequent and heavy rains in New Jersey during the growing season. The fact that the best results were obtained with the positive-charged natural cryolite shows that the material adhered very well and did not wash off easily. Synthetic cryolite and barium fluosilicate were also found to be quite affective. Magnesium arsenate showed up better as a spray than as a dust, but in no case did it excel the fluorine compounds. The results over the whole field were so variable that only a difference of 10% was significant. The percentage of injured beans in three cases was as follows:

Positive-charged natural cryolite	14.1
Magnesium arsenate	41.0
Check	58.8

The figures for the other plots ranged from 20.2 to 37.1 per cent.

In two other field tests of a similar nature, natural cryolite showed up 2 to 2.5 times as effective as magnesium arsenate.

LABORATORY TESTS WITH THE MEXICAN BEAN BEETLE.—In field tests one can never be sure that the insect infestation is uniform over the field, or that an insecticide is a repellent, or how toxic it is to the insects. To supplement the field work, some experiments with the Mexican bean beetle were carried on in cages in the laboratory. An arrangement called the "Cafeteria Method" was used to test the insecticidal preferences of the beetles. It consisted of a flower pot filled with sand into which the desired number of test-tubes were placed. They were filled with water, and the stems of leaves which had been dusted with different insecticides, were placed into them. A roomy wire cage was then set over the whole flower pot, and 100 adult Mexican bean beetles were introduced. As the beetles are phototropic, it was found necessary to place the cage in full sunlight, in order that the beetles should not be influenced in their choice of leaves. The experiment lasted 24 hours, and at definite intervals the leaves were examined and the number of beetles feeding on each one was recorded. In one series of cages, six leaves were used, each treated with one of the following insecticides: natural cryolite and talc, positive-charged natural cryolite and talc, synthetic cryolite and talc, barium fluosilicate and talc, magnesium arsenate and lime, and an untreated check. All the materials were used at 25–75% strengths. Table 1 shows the average number of beetles observed feeding on the different leaves in four different cages during 24 hours.

TABLE 1. AVERAGE NUMBER OF MEXICAN BEAN BEETLES OBSERVED FEEDING ON BEAN LEAVES DUSTED WITH DIFFERENT INSECTICIDES. 100 BEETLES IN EACH CAGE

Natural Cryolite	Nat. Cryolite Positive Charge	Synthetic Cryolite	Barium Fluosilicate	Magnesium Arsenate	Check
1.2	6.2	2.7	3.0	10.8	36.2
0.8	4.8	0.7	2.2	15.8	29.8
1.0	6.5	2.5	1.7	2.7	29.0
3.7	4.7	7.0	3.2	21.0	28.2

In Figure 87, six leaves taken from one cage show the close correlation between the number of insects observed on the leaves and the amount of feeding. There seems to be an indication of a repellent action by the fluorine compounds.

SOLUBILITY VERSUS TOXICITY.—Since fluorine is the toxic principle in fluorine insecticides, a study of the solubilities of various fluorine compounds was made and data are here presented to show the close correlation between the amount of fluorine available and the toxicity. The two insects, the Confused Flour Beetle, *Tribolium confusum* Duval, and the Honey Bee, *Apis mellifica* Linn., used in this study, were chosen because they represent almost the two extremes in the matter of food digestion. The flour beetle does not imbibe any moisture with its food, therefore, all the chemical reactions must occur within the insect's alimentary canal. These reactions are necessarily much slower than in the case of the bee, where all the food is of a liquid nature.

FLOUR BEETLE EXPERIMENTS.—The flour beetle experiments were carried on in small shell vials. The two insecticides used were mixed with flour to the desired concentrations. Twenty beetles were added to the

material in each vial, and a piece of cheese-cloth was put over the top. This insect was found to be extremely reliable for toxicity studies. During the course of the work, none of the beetles used as checks died, and of the starvation checks, the first one did not die until the eighteenth day. The insecticides used were lead arsenate and a fine grade of natural

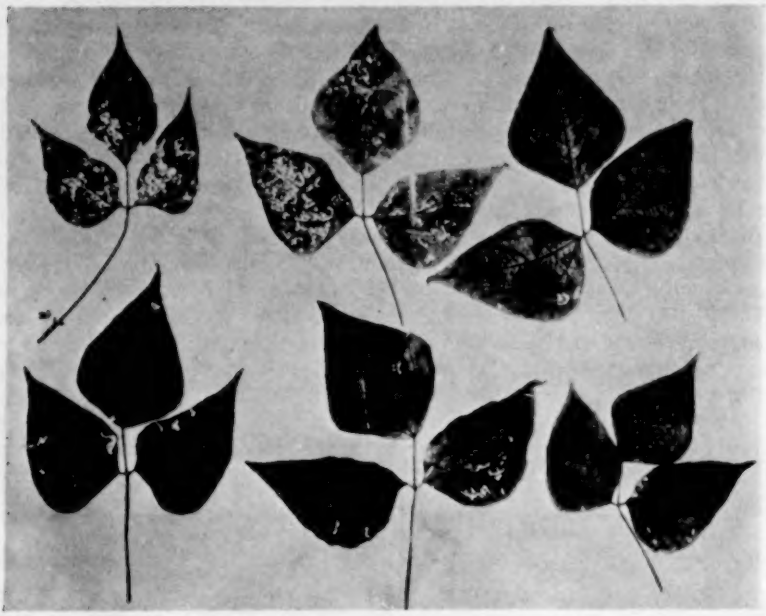

FIG. 87.—Bean leaves showing amount of chewing by the Mexican Bean Beetle. Top—Left to right—Check, magnesium arsenate, natural cryolite. Bottom—natural cryolite positive-charged, synthetic cryolite, and barium fluosilicate.

cryolite, in which all the particles were 5 microns or less in size. These two insecticides were used at concentrations of 100, 80, 60, 40, and 20%. The readings for toxicity were made on the 3rd, 5th, and 8th days. The data are given in a histogram, Figure 88. Lead arsenate at 100% is very toxic, but on the 8th day, the natural cryolite surpasses it. At 80 and 60%, lead arsenate and natural cryolite are about equal, but, at the 40 and 20% concentrations the lead arsenate drops behind, and the natural cryolite shows a 60% mortality on the 8th day.

Since the Confused flour beetle is so closely connected with food products, the two stomach poisons used in this experiment would scarcely be used in practical control measures. The results are, therefore, of an indicative nature as regards the question of solubility of the two insecticides used.

HONEY BEE EXPERIMENTS.—The experiments with the honey bee were designed to show how natural cryolite reacts with lime, bordeaux, and lead arsenate; and also, to show that toxicity depends upon the

solubility of a compound, and that in the fluorine compounds the toxicity is tied up with the amount of fluorine present and available in the compound.

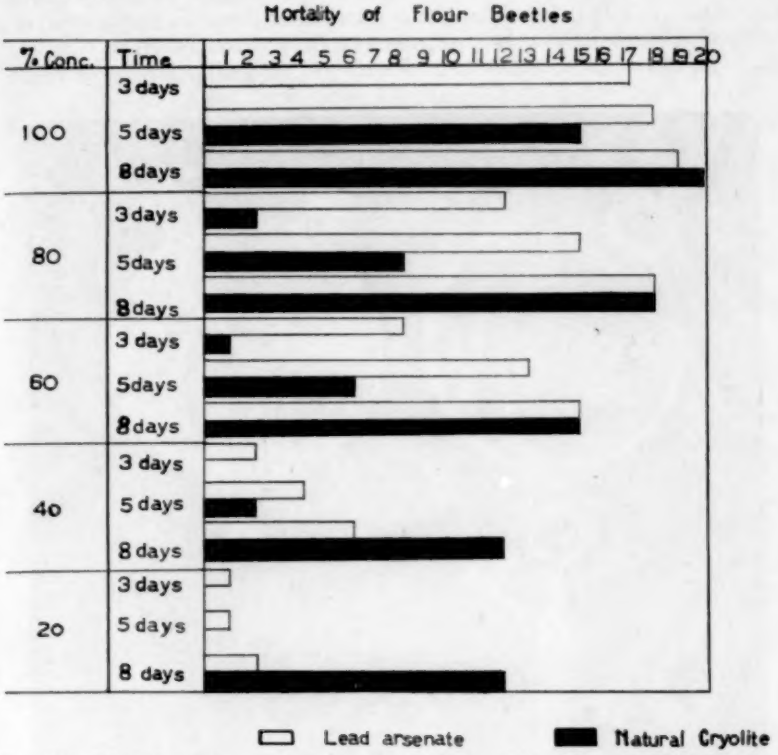

FIG. 88.—Relation between concentration of insecticides and mortality of the flour beetles.

The honey bee was found to be an excellent indicator of the toxicities of various stomach insecticides such as the fluorines and arsenicals. The results obtained in these laboratory tests cannot, however, be applied directly to field conditions. The insecticides in these experiments had to be administered in a cane sugar syrup which would tend to disguise them. It was noted in the case of other insects that the fluorine insecticides seemed to have a repellent action. This fact was not noticed in the laboratory tests with bees, but probably in the field repellency might be an important factor.

A great many methods of feeding the bees were tried until one was found which gave very satisfactory results. This method is so simple and so easy to reproduce that it was thought worthwhile to give it in detail. The apparatus consists of a wire sieve, 5 inches in diameter and 4 inches deep. A bottom of stiff cardboard is cut to fit, (Figure 89), and three

elastic bands hold it firmly in place. It was found that this sieve could accommodate 25 bees in the matter of food. If 50 bees were used the results were not as reliable. The wire of the sieve is coated with wax before using. The liquid food is put on top of the sieve with a brush and forms a film in the interstices of the wire, held there by surface tension. The food of the bees consisted of a heavy cane sugar syrup to which was added the material in water to make up a 0.36% solution or suspension

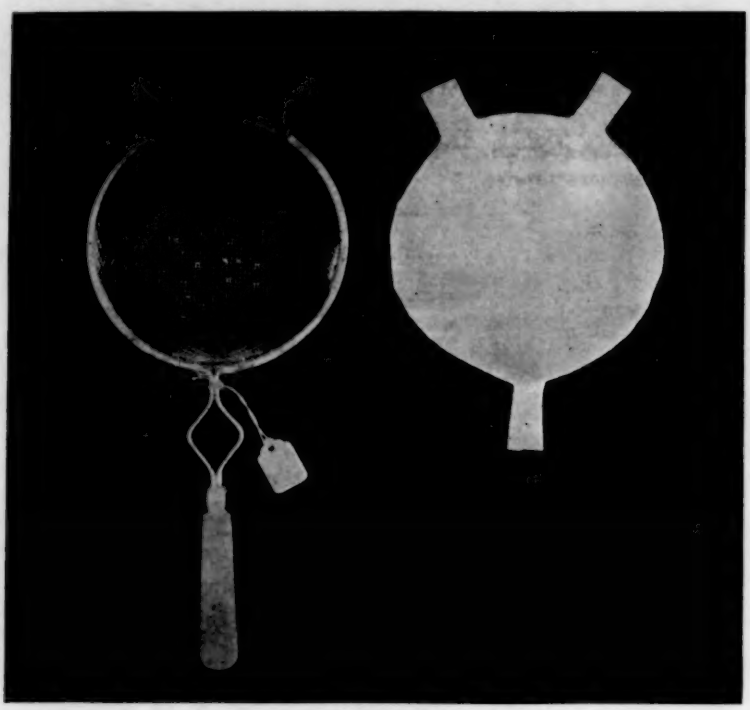

FIG. 89.—Sieve and cardboard bottom used as feeding cage for bees.

of the insecticide. This per cent was used because it represents a ratio of 3 pounds of insecticide to 100 gallons of water. It was found that this amount of the insecticides used gave a normal distribution curve of toxicity, and that the duration of the experiments was about the right length of time to offset any disturbing factors which might enter over a long period of time. When the 25 bees were put into this sieve-cage and given food, upon which they would start to feed immediately, the sieve was then placed into a box about two feet square. This box was lightproof and the temperature in it could be maintained from 18° to 20° C. during the course of the experiments.

Since bees vary greatly in their responses according to the temperature, light, time of day and time of year, all these factors must be noted.

The experiments reported in this paper were performed during the month of October, at which time the bees were behaving normally due to the warm weather. The bees for each series of experiments were taken out of the hive in the morning and were fed on the test materials within an hour. The sieve-cages were examined at definite intervals during the experiment, and the number of dead bees recorded. The results are given in Table 2, showing the number of hours it took to obtain the 50% toxicity point. Each lot represents a group of bees taken from the hive at the same time and subjected to the same experimental conditions, except for the difference in food.

TABLE 2. LIST OF MATERIALS FED TO BEES SHOWING THEIR RELATIVE TOXICITIES

Materials used 0.36% solutions or suspensions	50% toxicity time in hours
Lot I. (Cryolite and Lime)	
Natural cryolite	8
Natural cryolite and lime 1:½	20
Natural cryolite and lime 1:1	26
Natural cryolite and lime 1:2	35
Lot II. (Arsenicals)	
Lead arsenate	24
Magnesium arsenate	22
Calcium arsenate	2
Sodium arsenate	2
Lot III. (Fluorides and Bordeaux)	
Barium fluosilicate—$BaSiF_6$	4
Synthetic cryolite—Na_3AlF_6	4
Natural cryolite—Na_3AlF_6	8
Natural cryolite and Bordeaux 1:1 (Lime-Free)	4
Natural cryolite and Bordeaux 1:2 (Lime-Free)	4
Lot IV. (Fluorine Compounds)	
Barium fluoride—BaF_2	8
Iron fluoride—FeF_3	21
Sodium fluosilicate—Na_2SiF_6	2.5
Zinc fluosilicate—$ZnSiF_6$	4
Lot V. (Fluorine Compounds)	
Potassium fluoride—KF	4
Ammonium fluoride—NH_4F	1.75
Ammonium bifluoride—NH_4HF_2	1
LOT VI. (Fluorine Compounds)	
Sodium fluoride—NaF	4
Calcium fluoride—CaF_2	–
Natural cryolite	8
Natural cryolite and lead arsenate 1:1	8
Lot VII. (Filtered Supernatant Liquid)	
Natural cryolite	23
Starvation check	20
Lot VIII. (Natural Cryolite)	
Natural cryolite	8
Natural cryolite—0.72% suspension	4

Carter (9) has shown that lime is incompatible with the fluosilicates. That lime markedly decreases the toxicity of natural cryolite is clearly shown by the results obtained in Lot I of the bees (Table 2). The addition of increasingly larger amounts of lime destroys the toxicity of cryolite in the same proportions. A chemical reaction takes place in which the fluorine combines with the calcium to form the relatively insoluble calcium fluoride, thus rendering the cryolite less toxic to the bees.

When lead arsenate is added to cryolite the time for 50% toxicity of the bees is the same as for cryolite alone. It would seem, therefore, that there is no chemical reaction between these two materials. When Bordeaux is added to cryolite, however, the time for 50% mortality of bees

is one-half that of cryolite alone. Since the material must be fed to the bees in a sugar solution, it is probable that the Bordeaux has reacted with the sugar with the result that the amount of water-soluble copper is increased. Fleming (10) used Bordeaux with the fluosilicates and came to the conclusion that "the increase in amount of water-soluble copper in the combination is due to the formation of some copper fluosilicate".

There is a striking difference in the reaction of the bees to fluorine and lead arsenate poisoning. Fluorine insecticides cause the bees to die rather suddenly, whereas those fed on lead arsenate become sick shortly after feeding and then stagger around weakly until they cannot stand on their feet. They remain in a comatose state lying on their backs for many hours before they can be pronounced dead.

A selection of fluorine compounds was made on the basis of their solubilities. Their toxicities are listed in Table 2, Lots IV, V, VI.

The close correlation between the toxicity and the solubility of the fluorine compounds is shown in Table 3.

TABLE 3. TOXICITY TO BEES CORRELATED WITH AMOUNT OF FLUORINE PRESENT AND AVAILABLE

Chemical	Sol. in gms./100 mls. cold water	Gms. fluorine/100 mls. 0.36% sol. or suspension	50% toxicity time
NH_4HF_2	Very soluble	0.2400	1 hour
NH_4F	Very soluble	0.1847	1¾ hours
NaF	4.0 at 15° C	0.1629	4 "
KF	92.3 at 18°	0.1177	4 "
Na_2SiF_6	0.652 at 17° C	0.218	2½ "
BaF_2	0.17 at 10° C	0.0781	8 "
CaF_2	0.0016 at 18° C	0.175	
Na_3AlF_6 (Natural)	0.36 at 18° C	0.1766	8 "
Na_3AlF_6 (Synthetic)	0.62 at 18° C	0.1897	4 "
$BaSiF_6$	0.026 at 18° C	0.1462	4 "

The first five compounds listed,—ammonium bifluoride, ammonium fluoride, sodium fluoride, potassium fluoride, and sodium silicofluoride, are quite soluble and, therefore, the amount of fluorine in solution can be directly calculated. In the case of the other five materials,—barium fluoride, calcium fluoride, natural cryolite, synthetic cryolite, and barium fluosilicate, the values for fluorine are only theoretical. The stated amount of fluorine is present but, due to the slight solubilities of these materials, not available. Note the two figures representing the amount of fluorine present in a 0.36% suspension of calcium fluoride and of natural cryolite. In calcium fluoride there is theoretically available 0.175 grams fluorine in 100 mls. of a 0.36% suspension. The solubility of this material in water has been reported as 0.0016 gram per 100 mls., and yet, insofar as toxic effects are concerned, there seems to be no fluorine available, as shown by the fact that not a single bee fed on this material died in four days. Even after 8 days the 50% mortality point was not reached.

From the reactions of lime with cryolite, of calcium fluoride, and of all the other fluorine compounds on bees, it would seem that the fluorine compounds act upon living tissues by taking up the available calcium to form the almost insoluble calcium fluoride. Since insects have so little calcium in their composition in comparison with the warm-blooded animals, it might explain why the fluorines act so quickly upon insects and are so much more toxic to them. Though these experiments were

conducted upon insects, the underlying biochemical principles should hold for the higher animals. The idea, therefore, suggests itself that probably there would be little injury from fluorine residues to a person who has a normal diet in which the amount of calcium is sufficient to accommodate the additional fluorine.

SUMMARY.—The fluorine compounds, and particularly natural cryolite, were found to be quite specific in the control of the tobacco flea beetles, *Epitrix parvula* Fabr. and *E. cucumeris* Harris, the eggplant flea beetle, *E. fuscula* Crotch, and the Mexican bean beetle, *Epilachna corrupta* Mul.

In field tests natural cryolite showed up as 2 to 2.5 times as effective as magnesium arsenate against the Mexican bean beetle.

Feeding experiments with the confused flour beetle, *Tribolium confusum* Duval, showed that natural cryolite is more toxic than lead arsenate at the lower concentrations.

Lime is incompatible with natural cryolite. Feeding experiments with bees showed that the toxicity of cryolite was markedly decreased by the addition of lime.

The toxicities of the fluorine compounds studied were in close correlation with the amount of fluorine present and available in a solution or suspension.

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PRELIMINARY STUDIES ON STARVATION AND DROWNING OF THE CHINCH BUG, *BLISSUS LEUCOPTERUS* (SAY)[1]

By M. J. JANES, ANNA HAGER, and G. E. CARMAN

During the summer of 1934 studies were conducted to determine the ability of the chinch bug, *Blissus leucopterus* (Say), to withstand starvation and submergence in water. Several thousand insects, representing the various instars, were employed. In connection with starvation, determinations were made on daily weight loss and also on the prolongation of life accompanying the feeding of distilled water and solutions of sucrose.

These studies were made for the purpose of determining what effect such factors as food shortage and heavy rains might be expected to have on chinch bug migrations and population building.

Britcher[2] in 1903 conducted several experiments on submergence of the chinch bug. His material consisted entirely of adults, including both long and short winged forms. He found that the insects were able to withstand alternate submergence and drying for periods of several hours and concluded that complete submergence in water, even for a considerable period, was not necessarily fatal.

EXPERIMENTS ON STARVATION.—The insects used for these experiments were nymphs and adults of the long winged form obtained for the most part from the field. In some cases the early instars were reared in the laboratory. The insects for each determination were selected at random and confined in shell vials, ten insects in each vial, without food or water under constant conditions of temperature and relative humidity. Observations were made at four or six hour intervals and the number dead was noted. Typically 200 insects of each instar were used for each combination of temperature and humidity. The temperatures employed were 24.5° C., 29.5° C. and 34.5° C., and the relative humidities were 70% and 90% except in the case of fourth instar insects confined at 34.5° C., when determinations were also made of the rate of starvation at 10%, 30% and 50% relative humidities. Temperature deviation did not exceed 0.5° C.

Table 1 summarizes the results obtained from the starvation experiments by giving the limits of the period over which death by starvation occurred for each instar at each combination of temperature and humidity, and also the time required for approximately half of the insects in each experiment to die. The death rate was gradual at the beginning of the starvation period and also toward the end when only a few individuals remained alive, as is shown in Fig. 90 which represents the death rates of the various instars at 29.5° C. and 70% humidity. As these curves show, the early nymphal instars and the adults are less able to withstand starvation than are the later nymphal instars. This was found to be generally true under all the temperature and humidity

[1]Journal Paper No. J201 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 420.

[2]Britcher, W. H. The Chinch Bug in Maine. Maine Agr. Exp. Sta. Bul. 91: 41–52. 1903.

conditions studied although the relative resistance of the various instars was not always the same. As one may determine by referring again to

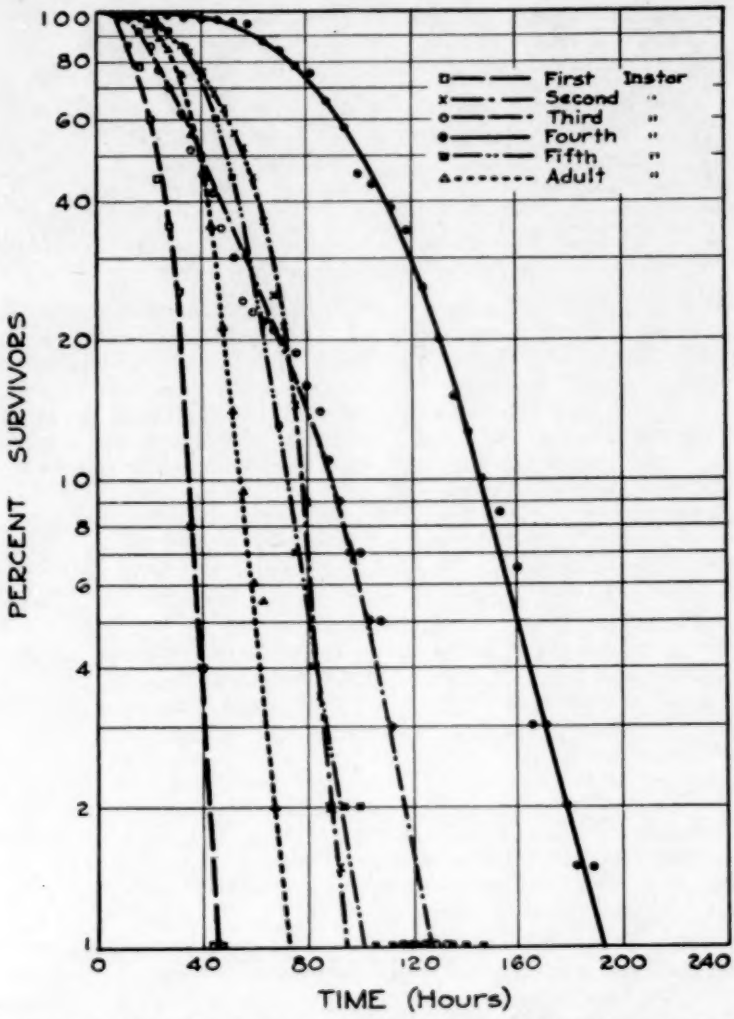

FIG. 90.—Survival curve of the various instars of *Blissus leucopterus* at 29.5° C. and 70% relative humidity. The numbers of insects employed were as follows: First instar, 180; second, 200; third, 400; fourth, 200; fifth, 800; adult, 200.

Table 1, the insects in the fourth instar in some cases existed longer than those of any other instar, for example, at 29.5° C. and 70% humidity as shown in Fig. 90, whereas in other cases those of the third or the fifth instar were able to live longer than those of the fourth instar.

TABLE 1. SUMMARY SHOWING LIMITS OF ENDURANCE OF *Blissus leucopterus* TO STARVATION

Instar		24.5° C. Relative humidity		29.5° C. Relative humidity		34.5° C. Relative humidity	
		70%	90%	70%	90%	70%	90%
1	Range	8–100 hrs.	8–132 hrs.	8–52 hrs.	8–64 hrs.	8–48 hrs.	8–64 hrs.
	Mid-point[1]	48 "	56 "	24 "	20 "	24 "	16 "
2	Range	8–172 "	8–204 "	8–100 "	8–100 "	8–88 "	8–92 "
	Mid-point	68 "	92 "	56 "	48 "	40 "	36 "
3	Range	20–212 "	20–308 "	16–136 "	16–208 "	12–80 "	12–140 "
	Mid-point	104 "	148 "	36 "	108 "	28 "	84 "
4[2]	Range	16–208 "	16–238 "	16–238 "	16–172 "	16–200 "	24–192 "
	Mid-point	46 "	52 "	100 "	40 "	72 "	88 "
5	Range	20–314 "	20–284 "	16–154 "	16–202 "	20–122 "	26–218 "
	Mid-point	86 "	98 "	52 "	56 "	50 "	110 "
Adult	Range	16–188 "	16–112 "	20– 88 "	16–108 "	16–108 "	16– 72 "
	Mid-point	48 "	52 "	40 "	48 "	28 "	32 "

[1]Time at which approximately half of the insects in each experiment were dead.
[2]For fourth instar nymphs at 34.5° and 10% humidity, the range was 8–76 hours; at 30% humidity, 8–88 hours; at 50% humidity, 8–108 hours. The mid-points were 32 hours, 44 hours and 40 hours respectively.

Fig. 91 is typical of the results obtained when the death rates at the various temperatures were compared. The insects used for this experiment were in the second instar and were maintained at 70% humidity, but approximately the same relationship was found to exist between the death rates of other instars at other humidities when only the temperature factor was varied. As Table 1 indicates, in only one case, that of the fourth instar insects, did the death rate at one temperature ever exceed that at the next higher temperature.

Somewhat less constant results were obtained when the humidity factor alone was varied. In general, however, it may be seen from the table that higher death rates accompany lowered humidities, and Fig. 92 which shows the death rates of insects in the fourth instar at 34.5° C. may be taken as typical of the results obtained.

Ecdysis frequently occurred during the period of starvation, but in no case did it occur more than once for any one insect.

It must be emphasized that the experiments were of a preliminary nature. However, the results obtained would seem to indicate (1) that chinch bugs may live for from eight hours to thirteen days without food or water, (2) that the majority of deaths occur during the second, third and fourth days of starvation, (3) that the later nymphal instars are able to withstand longer periods of starvation than the early instars or the adults, (4) that death from starvation occurs earlier at the higher temperatures and (5) that lower relative humidities are usually accompanied by more rapid death rates.

STARVATION WITH WATER AND SUCROSE AVAILABLE.—As a variation of the starvation tests, some experiments were performed in which the starving bugs had access to cotton sops of distilled water. These experiments were conducted to determine the ability of chinch bugs to obtain sustaining benefit from other sources than host plants during migration. One hundred insects of each of the fourth and fifth instars and the adult stage were maintained, ten in a vial, in each of the constant temperature chambers. The humidity was maintained between 90% and 100%. The cotton sops were placed in small vials which in turn were firmly wedged with cotton in larger shell vials. Precaution was taken to eliminate all frayed or loose surfaces which might cause the insects to become en-

tangled. Daily readings were made and the number dead recorded. The results of the experiments on complete starvation were used as controls.

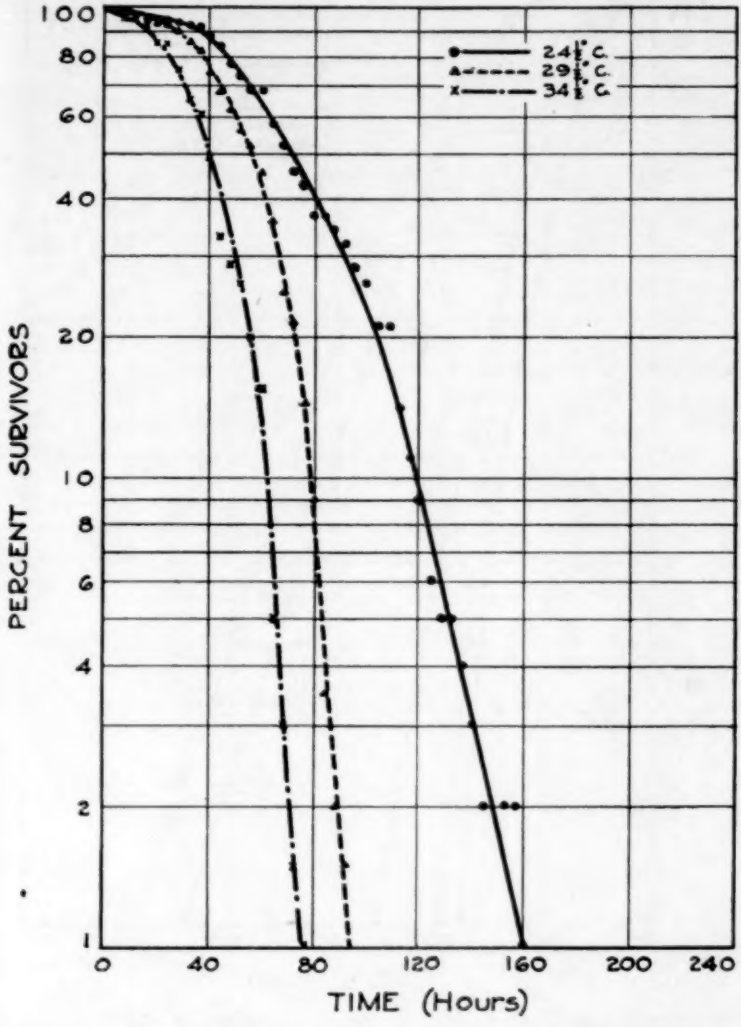

FIG. 91.—Survival curve of second instar *Blissus leucopterus* at 70% relative humidity, at various temperatures. The numbers of insects employed were as follows: 188 at 24.5° C., 200 at 29.5° C., and 200 at 34.5° C.

Previously starved individuals given access to a distilled water sop and observed with their beaks protruded for from ten to twenty minutes, apparently feeding, showed no measurable increase in weight. Such

individuals showed a subsequent increased ability to withstand starvation.

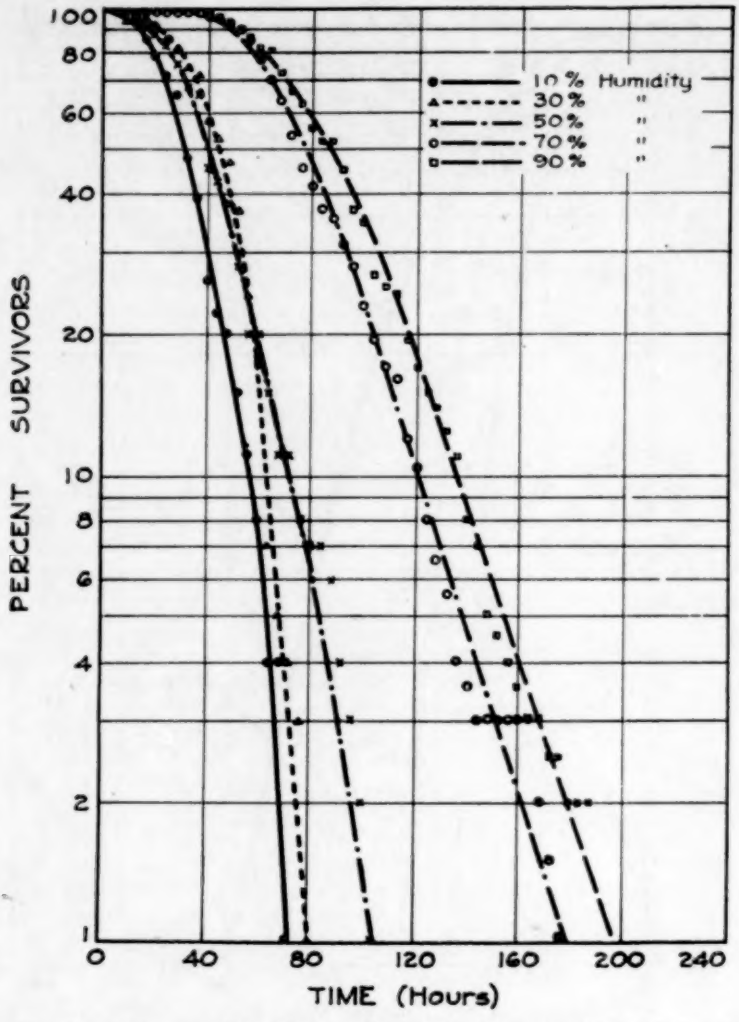

FIG. 92.—Survival curve of fourth instar *Blissus leucopterus* at 34.5° C., at various humidities. The numbers of insects employed were as follows: 100 at 10% relative humidity, 100 at 30%, 100 at 50%, 200 at 70%, and 186 at 90%.

In every case the insects which had access to distilled water lived longer than the controls, in some instances as much as five times as long (Fig. 93). Table 2 gives the extreme limit of time that the insects were able to live at the various temperatures and also the point at which

approximately one-half were dead. It may be seen that the greatest gain in ability to withstand starvation occurred at the low temperature.

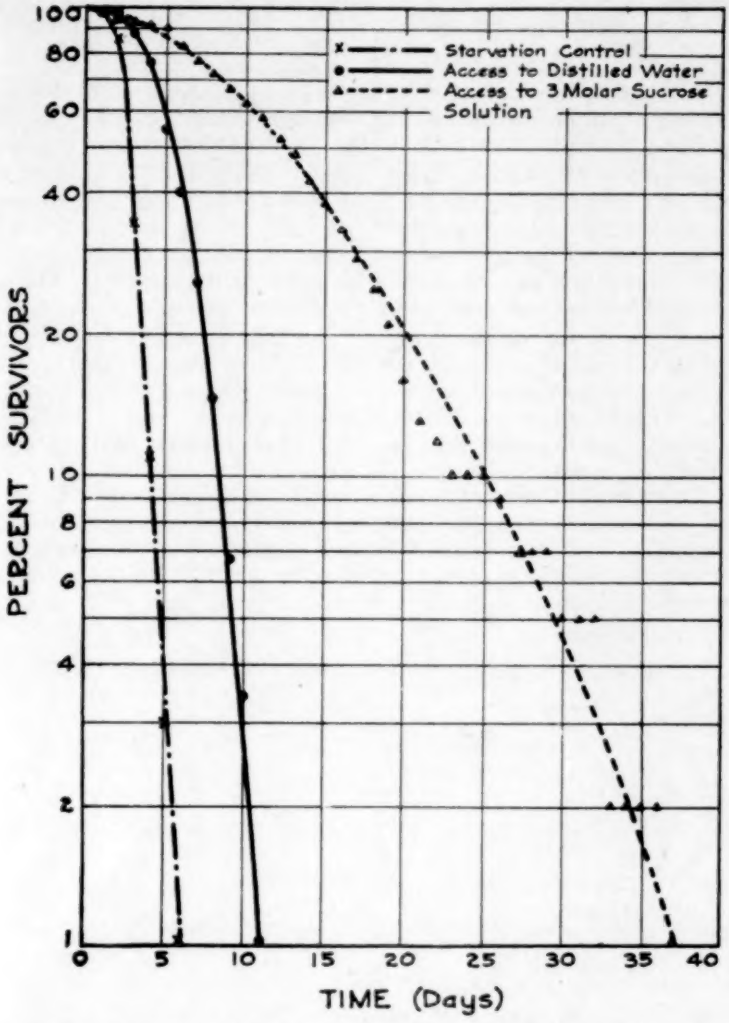

FIG. 93.—Survival curve of adult *Blissus leucopterus* at 30° C. and 90–100% relative humidity, under varied starvation conditions. Each curve shows results for 100 insects.

There was very little prolongation of life at the high temperature. There was more difference in the death rates, at the various temperatures, of those insects given access to water than of those without it.

TABLE 2. SUMMARY SHOWING LIMITS OF ENDURANCE OF *Blissus leucopterus* TO STARVATION WHEN GIVEN ACCESS TO WATER OR SUCROSE

		24.5° C.		29.5° C.		34.5° C.	
	Instar	Limit	Median	Limit	Median	Limit	Median
Distilled water...	4	11 days	5 days	11 days	5– 6 days	19 days	10 days
	5	11 days	5 days	13 days	8– 9 days	18 days	11–12 days
	Adult	11 days	5–6 days	15 days	6– 7 days	20 days	8 days
3 Molar sucrose..	Adult			37 days	12–13 days		

As a further variation, cotton sops of a three molar solution of sucrose were made available in the case of 100 adults kept at 29.5° C. As is indicated by the table, the period of life was considerably lengthened.

EXPERIMENTS ON WEIGHT LOSS.—Daily weight determinations were made of 100 adults during the period of starvation. Each day the insects which had died since the previous determination were removed in order that weight loss resulting from putrefaction should not be confused with weight loss resulting from starvation. Fig. 94 shows the mean weight of the live insects from the time of their confinement until all were dead.

EXPERIMENTS ON SUBMERGENCE.—In the drowning experiments, insects were confined in wire gauze cages, approximately fifty in a cage, and completely submerged in distilled water which was maintained at 24.5° C. These cages were removed from the water, one at the end of each successive four hour interval. The insects taken from each cage were confined on wheat plants for 48 hours, after which time the per cent which had sufficiently revived to be capable of feeding was determined.

Four experiments were conducted in which the adults and the last three nymphal instars were used. Insects confined on host plants during the entire period of time were maintained as controls. In two additional experiments, fifth instar nymphs and adults were submerged in tap water which was standing over soil from a corn field.

TABLE 3. SUMMARY SHOWING PER CENT OF *Blissus leucopterus* RECOVERED AFTER SUBMERGENCE IN WATER AT 24.5° C.

Hours submerged	Per cent recovered					
	Submerged in Distilled water				Submerged in tap water over soil	
	3 instar	4 instar	5 instar	Adult	5 instar	Adult
4	100.0	97.6	100.0	100.0	96.3	86.0
8	86.9	96.0	88.1	100.0	98.0	92.4
12	89.6	95.8	84.0	84.9	92.3	74.0
16	80.8	90.9	87.3	80.4	82.0	17.0
20	79.5	93.7	86.9	67.9	81.1	3.7
24	71.7	92.7	65.3	58.1	60.9	18.0
28	92.7	70.4	39.1	58.8	52.3	14.0
32	86.7	75.0	50.0	18.2	15.2	4.2
36	78.1	74.5	33.3	5.7	37.0	0.0
40	51.3	72.3	68.0	0.0	8.3	0.0
44	27.1	53.3	12.2	0.0	47.2	0.0
48	6.4	28.0	2.1	0.0	0.0	0.0
52	0.0	0.0	0.0	0.0	0.0	0.0

A very small per cent of the submerged insects (Table 3) was able to recover after 48 hours in distilled water; none was able to withstand submergence beyond 52 hours. When comparisons are made with the mortality of the controls, it seems plausible that a few died from drowning during the first four hours. Insects submerged in water over soil were killed more readily than those confined in distilled water. Especially was this true in the case of the adults.

In all of the experiments in which distilled water was used the death rate over the first several hours increased quite gradually and was followed by a sudden acceleration toward the end of the period. Approximately 50% of the third instar nymphs were still able to recover after 40 hours of submergence. None recovered after 52 hours. Fourth instar

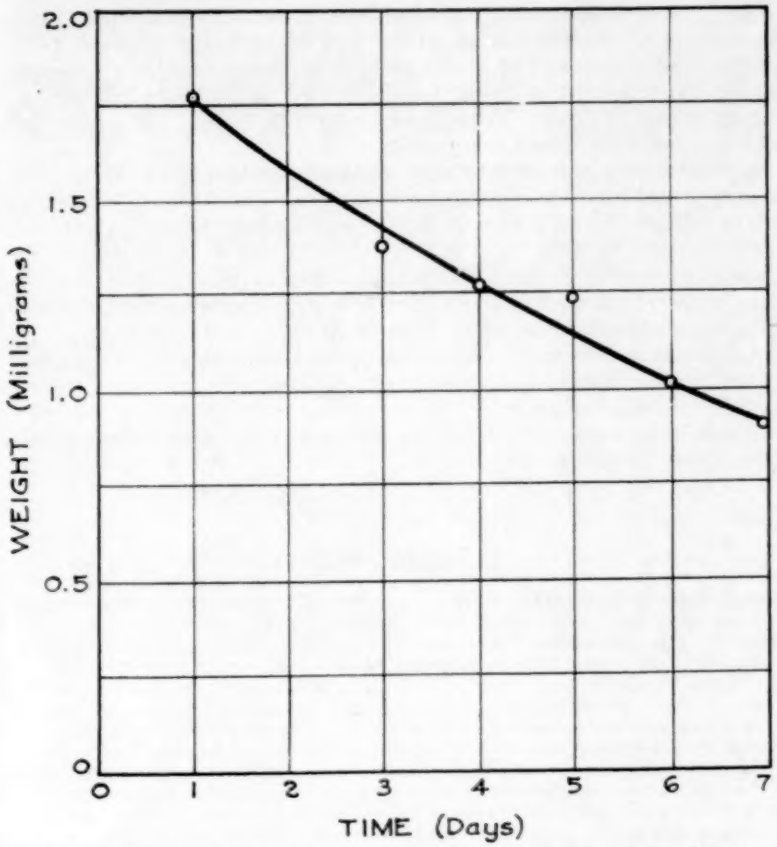

FIG. 94.—Daily weight loss of 100 adult *Blissus leucopterus* during starvation.

nymphs seemed to be more resistant than any of the other insects tried. Recovery had been reduced to 50% only after 44 hours. At the end of 48 hours 28% recovered. None was able to withstand 52 hours of this treatment. The 50% point for the fifth instar bugs was reached at about 28 hours. At 48 hours, 2.12% recovered; none survived beyond 52 hours. Adult insects were apparently less resistant than any of the nymphs. The 50% point was reached at about 30 hours, and all of the insects died within 40 hours.

Certain irregularities occurred in the results. An example of this is seen in the case of the fifth instar nymphs. After the survivors had been reduced to 33.33% at 36 hours, the next successive reading at 40 hours showed 69% recovery. These irregularities can hardly be explained on the basis of information obtained from the few experiments conducted.

In the case of fifth instar nymphs submerged in tap water over soil, the 50% point occurred at about 30 hours. None survived after 48 hours. The sample of insects taken at the end of 44 hours showed 47.17% recovery. This was one of the ouststanding irregularities encountered. The adults were practically all dead after 24 hours. Fifty per cent were dead at about 14 hours. None lived beyond 36 hours. They were again much less resistant than the nymphs.

Approximately 150 insects were used as controls for each instar. At the end of 100 hours of confinement on wheat plants the per cents alive were as follows: Third instar, 96.33%; fourth instar, 97.06%; fifth instar, 98.91%; adult, 99.02%.

SUMMARY.—Chinch bugs, *Blissus leucopterus* (Say), lived for a considerable period of time without food or water. Death occurred sooner at high temperatures or low relative humidities.

In every case insects having access to distilled water or to solutions of sucrose lived longer than the controls. An appreciable daily weight loss accompanied starvation.

Chinch bugs were able to recover in some cases after submergence in water for as long as 48 hours.

Scientific Notes

Estimating the Dosage-Mortality Curve. Several authors have shown that when the per cent of insect mortality observed is plotted against the dosage of poison administered, a sigmoid curve is obtained which, on appropriate coordinates, can easily be plotted as a straight line. In a recent paper (Ann. Appl. Biol. *22*, 134) I have described methods for computing such straight lines and the accuracy of their estimation, when the mortalities are converted to probits and the dosages to logarithms. One of the uses of the computed curve is for the determination of dosage or kill near or beyond the highest observed incomplete mortality. The reliability of estimates in this region will depend not only on the error of estimation, described elsewhere in detail, but also upon whether the rectilinear logarithmic-probit relationship is valid over the range in which the predicted value lies. It is desirable, therefore, that the function of dosages be used which seems to have the best biological basis, and for this purpose the logarithm has shown advantages. Without impairing the utility of the logarithmic transformation for the more important higher values, the occasional change in slope at the lower concentrations, as well as the agreement at the higher dosages, found a tentative explanation in terms of poison fixation. If, however, the logarithmic transformation is considered purely as a mathematical device for rectifying a curve, then each departure from rectilinearity at the lower dosages represents a failure in the method.

O'Kane, Westgate, and Glover (N. H. Agr. Expt. Sta. Tech. Bul. 58) have proposed that many curves showing this bend can be plotted as single straight lines by using the logarithm of the "mortality conversion value", a unit equal to 13.44447 probit —17.22235. The logarithm of a probit or of a multiple of a probit is not a natural function, but the same result can be secured by fitting to the data an equation of the form: $y = a + bx^c$, when x and y are the dose and probit (mortality) respectively and a, b, and c are constants. By O'Kane's method, the constant a is assumed

to be 1.281 and the other two are determined from the data. As a numerical illustration, Strand's data for the action of CS_2 upon Tribolium can be fitted approximately by the formula

$$y = 1.281 + 0.000101\ x^{3.57}.$$

Since the constant 1.281 is an arbitrary one, the fit can be improved if it, too, is estimated directly from the data, giving

$$y = 2.705 + 0.000000361\ x^{5.82}.$$

An equally good agreement can be obtained with the parabola

$$y = 3.065 + 0.00274\ (x - 33.56)^2.$$

In each case, the observations agreed with the computed curves within the sampling error over the entire range of concentrations, as judged by the X^2 test, but the function which is selected for use will modify the concentrations estimated from the computed curve, especially if extrapolated beyond the highest, partially-lethal concentration.

From the above equations and that for the logarithmic-probit relation when the two lowest concentrations were omitted, ie:

$$y = -40.385 + 25.51 \log x,$$

the concentrations have been computed that would be required to kill all but one survivor in 100 beetles, one in 1000, and one in 10,000 respectively.

Function of Dose	No. of mg./l. CS_2 for 5 hrs. needed to kill			
	Constants	99%	99.9%	99.99%
Exponential (O'Kane)	3	72.3	75.8	78.4
Exponential (*a* fitted)	3	72.8	75.7	78.0
Parabolic	3	73.3	76.4	79.0
Logarithmic	2	74.2	79.5	84.1

Although the logarithmic transformation required the omission of a few observations at the lowest dosages, it could be fitted with one less constant, allowed the biggest margin of safety in estimating concentrations for higher mortalities, and was consistent with theoretical considerations on the nature of the curve.

C. I. Bliss, *Galton Laboratory, University of London*

A Technique for Rearing the Corn Earworm, *Heliothis obsoleta* Fab. Although the adult forms of many species of insects are available throughout the year, insect physiologists and toxicologists are confronted with the difficult problem of procuring large-sized larvae during certain periods of the year for experimental and other purposes. This shortage of material became especially evident to the writer while conducting toxicity experiments, in which corn earworm larvae were being used. As the experiments were not completed by the first of October, at which time the larvae were becoming scarce in fields around Ames, Iowa, efforts were made to rear them in the greenhouse. Although an exhaustive study was not made, the writer feels that the technique developed for rearing the larvae will be of benefit to other investigators engaged upon similar problems.

The corn earworm, which breeds readily in capitivity, is peculiarly well adapted for rearing under greenhouse conditions. Furthermore, the large number of host plants on which it feeds simplifies the rearing of the larvae.

Fully mature larvae were collected from ears of corn during the last week of September and the first week of October. These larvae were allowed to pupate in the greenhouse, and in about two weeks the moths emerged. The moths were confined in a wire cage in which young corn was growing. Corn was also planted about the cage.

The moths were fed on a ten per cent sucrose solution, feeding being accomplished by placing a sponge saturated with the sucrose solution in the cage; water was also made available. Each day the sponge was washed and again saturated with a fresh sucrose solution. The moths fed readily on this solution, and in a couple of days after they emerged they began to oviposit.

The eggs were laid promiscuously on the sides of the cage and on the growing corn within the cage. If the moths showed a selection of places for oviposition, then it was the sides of the cage rather than the growing corn. The eggs began to hatch in four to five days following oviposition; observations indicated that there was a high degree of fertility.

After hatching, the small larvae congregated on the corn in contact with the cage, and in a couple of days, the evidence of their feeding became apparent. The plants were completely defoliated a few days later, except for the tough mid-ribs and veins of the leaves and the tough lower stems. Although the larvae are canabalistic, marked manifestation of such was not evident while the larvae were feeding on the exposed leaves.

Some of the larvae were allowed to reach maturity on the green corn plants, while others, third and fourth instar larvae, were placed on sweet corn that had been soaked previously for several days in water in order to soften the kernels. Feeding was accomplished by placing the larvae in small glass jars which contained some of the soaked corn and also some damp sand. The purpose of the latter was to keep the corn moist and soft. Only one larva was placed in each jar, and the top of the jar was then fastened to prevent the corn from becoming dry. The larvae which developed on the corn kernels were larger than those which reached maturity on the green succulent plants. The complete life cycle required about one month. The moths from this brood began to emerge about November 20. These moths were handled exactly as were those of the previous generation.

As it required a large amount of growing corn to rear the larvae, it was thought advisable, due to the small amount of foliage afforded by corn plants, to attempt to rear them on some other plant which would afford a more luxuriant growth of foliage. Consequently, rape, a succulent, rapidly, growing plant, was seeded in time for it to reach a height of several inches before the second brood larvae hatched. This plant proved to be excellent for the rearing of the larvae, and as it affords more food than corn on limited greenhouse space, it is to be preferred.

This second brood of larvae began to pupate about the first of December. The moths from these pupae were weak and the eggs which they laid were infertile. Although the writer was unable to rear the larvae throughout the winter, he believes that studies of conditions will enable this to be accomplished.

L. O. ELLISOR, *Department of Zoology and Entomology, Iowa State College, Ames, Iowa*

The Incidence of Screw Worms in Southern Texas and Louisiana in 1934. Screw worms, *Cochliomyia americana* C. & P. and *C. macellaria* Fab., constituted a serious problem in Louisiana in 1934. A survey from Corpus Christi, Tex., eastward along the Gulf Coast and extending through Louisiana showed that the heavy outbreak of screw worms in Louisiana and other Southeastern States was continuous and definitely connected with a heavy incidence along the Texas coast.

The Texas coast counties surveyed and the percentages of infestation as reported for the various classes of domestic animals by the owners, county agents, and others engaged in the control of this problem are tabulated below:

INFESTATION BY SCREW WORMS IN SOUTHERN TEXAS IN 1934

County (Texas)	Classes of animals and extent of infestation				
	Cattle	Horses and mules	Sheep	Goats	Hogs
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Refugio	9	16	7	16	30
Victoria	23	13	30	23	34
Wharton	20	5	—	—	17
Liberty	27	12	15	14	13
Jefferson	8	12	—	—	—
Orange	8	—	—	—	4

In Louisiana practically every parish in the southern half of the State and most of the eastern parishes lying along the Mississippi River to the northern border of the State were involved. The following southern parishes were the most heavily infested: Allen, Beauregard, Calcasieu, and Cameron on the west and Tangipahoa, Washington, and St. Tammany on the east. Light to medium infestations existed in Evangeline, Rapides, Avoyelles, Point Coupee, Iberville, St. Mary, West Baton Rouge, East Baton Rouge, East Feliciana, St. Helena, St. Charles, and Jefferson. While all other southern parishes and those on the eastern border extending northward to the State line were reported as lightly infested, most of them contained scattered farms on which medium to heavy infestations occurred. Based on a rather extensive survey

in St. Tammany, Washington, Tangipahoa, Allen, Beauregard, Calcasieu, and Cameron parishes the myiasis incidence in the principal classes of domestic animals in these seven parishes was as follows: 7.4 per cent in 239,487 cattle, 4.5 per cent in 78,028 horses and mules, 13.8 per cent in 264,526 sheep, and 11.8 per cent in 209,776 hogs. Placing all four classes of animals in one group, there were 82,431 cases of screw worms in 791,817 animals, or an average infestation of 10.4 per cent.

The percentage of fatalities for cattle, horses, and mules, and for hogs, was generally considered to be low, but for sheep the death toll was very heavy, especially in St. Tammany, Beauregard, and Calcasieu parishes. The loss in sheep in St. Tammany was estimated by the parish agent at $32,000. In Beauregard and Calcasieu the death loss was estimated at from 50 to 75 per cent of the infested animals. According to this estimate and an average infestation of 10.4 per cent, there was a loss in these two parishes of from 11,000 to 16,000 sheep. In other southern parishes heavy losses in many herds of sheep which graze entirely on unfenced ranges were reported.

The total loss inflicted by the screw worm during the 1934 season will not be known definitely, but it is certainly one of the greatest that Louisiana livestock interests have ever charged to this insect.

E. W. LAAKE, *Entomologist, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture,*
Division of Insects Affecting Man and Animals

A Dewberry Fruit Worm. A tiny lepidopterous caterpillar (Fig. 95) has been found attacking the last berries to ripen in the dewberry crop at Butterville, Granite, and southeastern Sandy (Utah) during the years 1931–34, inclusive. The worms are seldom observed until after the fruits have been picked and marketed. The infestation is noticed when the berries are placed in water to be washed or cooked. At this time the active worms leave the berries and float to the surface of the water, much to the horror of the housewife. The worms which emerge from the berries vary in size from ⅛ to ¼ inch in length, being approximately one-tenth as thick as long. In color, the worms vary from white to yellowish, some being rather transparent. Because of the seriousness of the infestation, some of the late berries picked from infested districts during 1933 were refused by the stores.

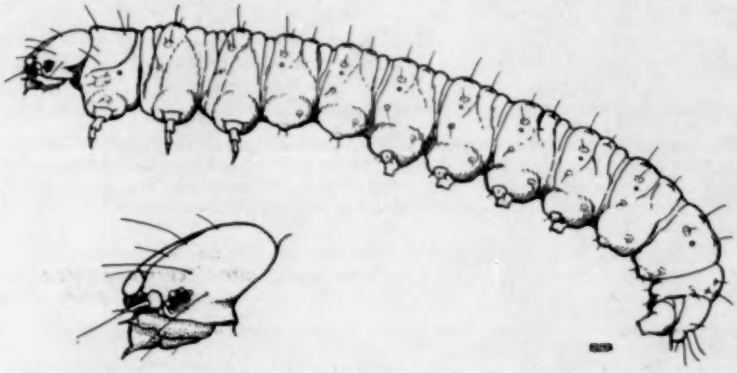

FIG. 95.—Larva of dewberry fruit worm, enlarged, head more enlarged.

Mr. Carl Heinrich of the U. S. Bureau of Entomology and Plant Quarantine examined larval material of this worm and determined it as a species of *Olethreutidae*, possibly *Ancylis comptana* Froel. An attempt was made to rear adults of this worm during the fall of 1934, but most of the specimens died in the pre-pupal stage, having transformed to this condition within a few days to two weeks after the infested fruits were picked from the bushes. It appears unlikely that any adults will emerge from the material collected during 1934.

GEORGE F. KNOWLTON, *Utah Agricultural Experiment Station, Logan, Utah*

***Petrobia tritici* (Ewing) On Onions And Its Control.**[1] Mites of this species were found on non-irrigated onions at Encinal, Texas, February 6, 1935. The adults were slightly more than one-half of a millimeter in body length but dark colored and easily seen; the young ones were light colored and smaller. While the wind was blowing they were found on low leaves or other protected places on the plants. During the night they went into the ground near the plant, but after the sun had shone for a few hours the mites returned to the plants. They ran rapidly or fell from the plants when disturbed. The mites were also found on plants in the seedbed, and on plants which were pulled and ready to be transplanted.

Dr. H. E. Ewing identified specimens and stated that "The species has been known only as a wheat pest in the past; that it occurs in the dry western part of the United States; and that its habits have not been studied."

The infestation increased from five per plant February 6 to 86 on March 15, 126 on March 19, and 330 mites per onion plant on March 26, 1935. The weather was dry from February 12 to March 30. Only three fields of about 275 acres were found to be infested by these mites, and these fields had been in onions continuously for the past several years. An onion thrips infestation was heavier in these fields than in others in the vicinity. The proportional damage caused by the mites and the thrips is not known, but it is suspected that the damage caused by the mites lowers the resistance of the plants to thrips attack. The plants were silver-colored and had a leathery texture which is typical of thrips damage, but this might have been partially caused by the mites. The total yield of all grades of onions was only about 30 bushels per acre for the eighty acre field in which these observations were made.

Experimental plats of about one-fifth of an acre were selected and treated March 15 from 7:30 to 8:30 A. M. while there was a heavy dew and no wind. Weather conditions were ideal for dusting, and the insecticides used adhered well and covered the plants. The sulphur continued to give off a strong odor for more than ten days. Fifteen pounds of dust and 200 gallons of spray were used per acre. The initial infestation on the day the applications were made was 86.1 mites per plant. The treatments and results are given in the following table:

Treatment 3/15/35	Average number of mites per plant 3/19/35	3/26/35
Sulphur*	4.7	0.3
Sulphur 90, Cube 10	13.1	0.3
Sulphur 85, Powco "A" 15	15.3	1.1
Pyagrol 1/400 spray	94.5	46.3
Loro 1/800, Penetrol 1/200 spray	82.5	36.5
Wettable sulphur 10/50 spray	101.0	40.2
Untreated	126.0	330.1

*A 300 mesh conditioned sulphur was used in all dusts.

These preliminary tests indicate that sulphur is a good insecticide to use in controlling this mite. The plats on which the more diluted sulphur dusts were used did not show as quick a reduction in the number of mites as where the conditioned sulphur dust was used. None of the materials gave any significant reduction in the thrips infestation.

S. E. Jones and W. H. Mecom, *Division of Entomology, Texas Agricultural Experiment Station, College Station, Texas*

[1]Approved by the Director of the Texas Experiment Station—Contribution by Division of Entomology, No. 326.

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A. A. A. S. Winter meetings, December 1935, St. Louis; December 1936, Washington; December 1937, Indianapolis, Ind. Summer meetings, 1935, Minneapolis; 1936, Rochester, N. Y.; 1937, Denver, Colo.

The last few weeks have witnessed an extraordinary outbreak by the eastern tent caterpillar. The probable developments in this direction were indicated in the abundant flight of moths last June, confirmed by the unusual abundance of egg masses upon the twigs in early July, and now there are many thousands lamenting the unsightly and pestiferous conditions. It is well known that the tent caterpillar is readily controlled. It appears to be difficult to bring home to the average man the desirability of adopting remedial measures before there has been extensive defoliation. It happens that the eastern tent caterpillar is not what might be called a serious pest, and yet the conditions existing in relation to this insect are more or less typical of those obtaining in regard to other insect pests. Commercial orchardists have learned the necessity for a planned program and timely applications in order to control insects. Is it too much to hope that in the near future there will be a more general appreciation of the importance of anticipating insect outbreaks and preventing injuries?

Some months ago attention was called to the extensive and very satisfactory work in insect control made possible from special funds and conducted under the direction of entomologists in different sections of the country. This is a comparatively new phase of activity in applied entomology and other opportunities in this direction should not be overlooked. During the summer and in fact, for some months thereafter, there must be innumerable entomological projects of many different kinds in various sections of the country, and those knowing such may well turn from the usual routine of activity, if there be such, to develop these phases and thus secure material advancement along scientific

lines and at the same time aid in relieving unemployment and benefiting the national welfare. The possibilities in this direction along entomological lines have by no means been exhausted.

Review

Lac and the Indian Lac Research Institute, by DOROTHY NORRIS, P. M. GLOVER and R. W. ALDIS. Pages 1–53. Criterion Printing Works, Calcutta, India, 1934.

This is an excellent and necessarily summary account of the Indian lac industry dealing first with the early history of the industry, the uses of shellac and the need for research. There follows a presentation of the work of the institute along bio-chemical, chemical and physico-chemical, entomological lines and the general activities of the organization. There are tabulations of lac production and a list of eighty Institute publications, with eight others in preparation, some in local dialects.

This small volume gives an excellent idea of an entomological activity comparatively rare in the United States, since the primary problem is to develop conditions favorable to the propagation of insects, to separate the more prolific and more productive races and to ascertain what trees and shrubs can be grown to best advantage in order to secure the maximum production. Lac is an important Indian product and the Lac Institute is concerned with the development of new uses or new markets for lac as well as increasing production.

E. P. FELT

Current Notes

Professor S. B. Freeborn was appointed, February 1st last, Assistant Dean of the College of Agriculture, University of California.

Professor W. B. Herms was decorated April 18 by the French Government with the rank of "Chevalier du Merite Agricole", the decoration being made in due form by M. Raymond Ricaud, Assistant Trade Commissioner.

Rocky Mountain Conference of Entomologists. The twelfth annual Rocky Mountain Conference of Entomologists will be held at the Colorado State College Forestry Lodge, Pingree Park, Colorado, August 18 to 23 inclusive. A principal topic for discussion will be "Diseases of plants and animals transmitted by insects (including ticks) and the insect vectors." Arrangements will be such that members of the family may enjoy a mountain outing during the Conference. Reservations should be made in advance. Further details can be secured by writing the Secretary, George M. List, Agricultural Experiment Station, Fort Collins, Colo.

The State Entomologist of the Wisconsin Department of Agriculture and Markets, reports an increased interest being shown by county beekeepers associations again in the control of American foul brood as evidenced by the increase in number of county appropriations being made to meet the state funds on the dollar per dollar basis. Fifteen counties appropriating from $50 to $500, have appropriated $3,000 for the work, while the state appropriation is $6,200. In 1931, 21 counties appropriated $4,700 and the state $10,500.

The Honorary degree of LL.D. (Doctor of Laws) was conferred on Arthur Gibson, Dominion Entomologist, Dominion Department of Agriculture by Queen's University, Kingston Ontario, at the Spring convocation on May 8th.

This honour comes to Dr. Gibson after over 30 years of notably distinctive work in the realm of entomology, 15 of which he has been Head of the Dominion Entomological Branch, one of the most important units of the Dominion Government Service. The activities of this branch are carried on from headquarters with its several divi-

sions in Ottawa and from 16 permanent laboratories, 11 temporary field stations and 10 plant inspection stations in different parts of the Dominion.

Dr. Gibson joined the staff of the Dominion Department of Agriculture in 1899 as assistant in the Division of Entomology and Botany, Central Experimental Farm, Ottawa. Six years later he was promoted to the position of Assistant Entomologist and in 1908 he was appointed Chief Assistant Entomologist. In 1914 the government decided to establish a separate entomological branch. In the new organization Arthur Gibson was selected as Chief of the Division of Field Crop and Garden Insects, because of the intensive study he had made and the diligence and ability he had displayed. On the death in 1920 of Dr. Hewitt, then Dominion Entomologist, Arthur Gibson was appointed his successor. In the past 15 years the work and services of the Entomological Branch have been extended and kept up-to-date to meet the increasing demands incidental to the growth and development of the country.

Horticultural Inspection Notes

News comes from Prof. A. G. Ruggles, state entomologist of Minnesota, that their appropriations were increased in all branches of the work so that funds will be available for the proper enforcement of the regulations provided for in their law, and that all the legislation requested by their office has been passed. The new statutes include (1) A new insect pest and plant disease law allowing county boards to appropriate funds for pest control, (2) Reciprocal law covering out-of-state nurserymen's license fees and (3) A new law providing registration of all agents selling stock in Minnesota.

According to P. A. Glenn, chief plant inspector of Illinois, the revision of the Illinois quarantine against the European corn borer, effective May 8, contains a provision which permits the admission into that state, under a special permit to be issued by the Department of Agriculture, of green sweet corn and corn on the ear from the counties in the southwest portion of the State of Indiana in which this insect has never been found. The counties from which such shipments are being permitted are Benton, Warren, Fountain, Vermillion, Parke, Putnam, Vigo, Clay, Owen, Sullivan, Greene, Monroe, Brown, Knox, DaViess, Martin, Lawrence, Jackson, Gibson, Pike, Dubois, Orange, Washington, Crawford, Posey, Vanderburg, Warrick, and Spencer. Prof. Glenn advises further that there is also a safety zone between the above named counties and the counties which in whole or part were under quarantine by the Federal government in 1932, in which the corn borer has not been found and was not found last year.

Plant Quarantine Import Restriction requiring certification of seeds and agricultural products intended for propagation being shipped into the Republic of Mexico are outlined in P.Q.C.A.-284, Supplement No. 11 issued recently by Lee A. Strong, Chief of the Bureau of Entomology and Plant Quarantine.

Supplementary Circular to 49-T issued October 16, 1934, adds seven nurserymen to the list of Pine-shipping permittees for the 1934–35 shipping season including four from Virginia, and one each from Idaho, Iowa, Maryland and Ohio.

Due to an undetermined disease which has attacked the azaleas in South Carolina, a quarantine regulation was placed by the State of Alabama, effective April 16, prohibiting the entry of these plants from South Carolina.

The Washington State Quarantine relating to the tuber moth was reissued on December 3 to include Utah and Hawaii in the infested territory, as well as California, Florida, Texas, and Virginia.

An amendment to the Federal quarantine relating to the Mexican fruit worm, under which Brooks county, Texas was added to the regulated area, was issued, effective March 19, and circular B.E.P.Q.-372, closing the shipping season on April 2, except for stored fruit, was issued on March 22.

The Oregon State quarantine relating to the chestnut blight was reissued on April 5 to provide for entry of nuts imported from foreign countries, when arriving in the State in unopened original containers.

A quarantine relating to the vetch weevil was placed by the Oregon Director of Agriculture on April 9, requiring fumigation of vetch seed brought into the state from New Jersey, Delaware, Maryland, Pennsylvania, North Carolina, and Virginia, and from foreign countries.

Pea weevil quarantines were recently placed by the States of Montana and Texas. Certification or fumigation is required for seed peas shipped to Montana and fumigation is required for shipments of peas to four counties in the Lower Rio Grande Valley in Texas where many acres are being planted in peas, commercially, for the first time.

Limited inspections for the citrus canker have been carried on cooperatively by Federal and State inspectors in Alabama, Mississippi, and Louisiana during the spring months. No infections were found in these states. More intensive inspections conducted under a similar arrangement in the Galveston area of Texas have resulted in finding infections on 19 properties in Galveston and Brazos counties during the first four months of the year. *Citrus trifoliata* trees were searched for in wooded bayous, vacant lots, and roadsides, as well as nurseries and home plantings, and 2086 such trees have been destroyed. These were principally wild trees and sprouts growing in wooded or abandoned places.

An amendment of the Mississippi rule relating to sweetpotato weevil which became effective February 1, places an embargo on sweet potatoes and the plants from the infested areas. Transportation of the restricted articles through Mississippi enroute to other States is conditioned on certification.

Washington State placed a quarantine (No. 21) on December 3, requiring that raspberry and blackberry plants shipped into the state must be free from mosaic as determined by two inspections during the growing season.

During the past winter a series of investigations were carried on at the various plant inspection ports in Canada, in connection with packing materials for commodities other than plants or plant products. Bark beetles both adults and larvae were found in several cases, when small limbs of trees or pieces of wood with bark on were used to reinforce large containers. Eggs of a species of locustidae were found on the bottom of a veneer case which originated in the United States.

New Jersey's part in the control of the Dutch elm disease is at a standstill at the present time due to the lack of funds, and the prospects for obtaining funds for the coming year are extremely poor. It now appears that if any progress is to be made in the control of this disease in New Jersey, such progress will have to be made by the Federal Government.

Large scale production of the nematode parasite (*Neoaplectana glaseri*) of the Japanese beetle is now being accomplished by the New Jersey Department of Agriculture. This parasite is being distributed at various locations within the State, and it is hoped that inroads will be made in the beetle population.

Following the discovery of an outbreak of the citrus red scale (*Chrysomphalus aurantii* Mack) in Arizona, directly traceable to imported nursery stock, Quarantine Order No. 4 was issued by the Arizona Commission of Agriculture and Horticulture, according to D. C. George, state entomologist. This regulation, intended to prevent the introduction and dissemination of the red scale on certain host plants from other states, requires that the common host plant listed be vacuum fumigated before arriving in Arizona. Plants of *Euonymous japonica* are embargoed by this act entirely except under a permit authorized by the state entomologist.

An act was passed by the New Jersey Legislature and became law on March 7, 1935, whereby the State Board of Agriculture is given authority to make inspections, issue orders, and condemn trees in connection with the control of the Dutch elm disease. This law gives representatives of the State Board of Agriculture the power

to enter upon any lands, public or private, within the State, for the purpose of making necessary inspections for the removal of condemned trees and for the disposition of the wood therefrom. An intrastate quarantine has also been set up by the New Jersey State Board of Agriculture, prohibiting movement of elms or any parts of elms from any point inside the regulated area to or through any point outside thereof.

According to T. L. Guyton, head entomologist of the Department of Agriculture of Pennsylvania, considerable outside scouting has been done in Pennsylvania in gypsy moth control. This inspection was carried on in twenty-three counties and included such places as environs of railroad stations, tourists' camps, public parks and summer hotels. No indication of gypsy moth was found outside of the present known area.

Until July 1, 1935, corn stalks and fodder will be permitted to be shipped into Colorado when sweetened and processed in hammer mills approved by inspectors of the Federal Bureau of Entomology and Plant Quarantine, according to George M. List, chief of the Bureau of Plant and Insect Control of that state. Supplement to European corn borer Quarantine No. 4, second series of the Colorado Bureau of Plant and Insect Control covering this order, became effective on May 1, 1935.

Believing that the production of potatoes in twenty-five counties of Colorado lying west of the Continental Divide where the Colorado potato beetle (*Leptinotarsa decemlineata* Say) is not known to be present, would be seriously endangered by the threatened movement of tomato and pepper plants into this area, quarantine order No. 5 (Second series), has been established. Tomato and pepper plants are admitted to this area only when accompanied by a certificate issued by the state official of the state of origin testifying to the fact that the county from which the plants came has been and is free from this insect.

By far the largest crop pest operation that the Virginia Department of Agriculture and Immigration has been engaged in during the past winter months has been the cutting and complete trimming up and destruction of our cedar trees in practically all of the commercial apple orchard counties of the state. Under the Virginia Cedar Rust Law, which was first adopted in 1914, many cedars have been cut. This was particularly true beginning in the winter of 1923. Since that time some trees have been cut each winter, but during the past five years the acreage cut over and the number of trees eliminated have been comparatively small until the present year. This large cutting operation during the past winter has been made possible by Federal relief allocations. At times there have been between one hundred and fifty and two hundred relief men engaged in this work. Mr. C. R. Willey, Associate Entomologist of the Department was in charge of the operation and obtained permission on the part of the owners in so far as possible. In the event authorization was not forthcoming they would then proceed under the Cedar Rust Law, issuing the usual notices to the owners and allowing them a fifteen-day period to file an appeal with the court which if done would stay further operations until the case was heard and instructions issued by the court. To date less than 15 appeals have been filed. Practically all of this work has been under way in six or seven or the Valley counties of the state; and a little more than $19,000 has been allocated by the Virginia Emergency Relief Administration.

Recent changes in the alfalfa weevil quarantines of the various states include (1) the omission of Union County, Oregon from infested territory in revisions of quarantines of Iowa, Kansas, Minnesota, Oregon, and Washington; (2) the omission of Nebraska in the quarantine established by Kansas on May 1; (3) the inclusion of Harney County, Oregon in the revision of the Minnesota quarantine which became effective on January 2; (4) the inclusion of San Juan County, Colorado in quarantines of Iowa, Kansas, Minnesota, Mississippi, and Wisconsin; (5) provision for the entry into Kansas, during the winter months, of hay that has been chopped and blown into the car by a blower making 2100 revolutions per minute; (6) the lifting of the Wyoming quarantine on hay and straw as to entry into Teton County, from any of the quarantined States during an emergency period from March 15 to June 1; and (7) the lifting of the Texas quarantine, during part of February, on alfalfa hay from Idaho, of grades U. S. No. 2 or better, when certified.

The revocation of the Federal quarantine relating to narcissus bulb pests on April 1, left the States free to act in placing any restrictions which seemed desirable. Word is received that Oregon has placed a special quarantine requiring spring and fall inspections, hot water treatment for nematode infestation, and similar treatment or fumigation for greater bulb-fly infestation; that in Florida, Virginia, Pennsylvania, and Michigan, inspections will be made the same as when the Federal quarantine was in force; that Maryland officers intend to continue the inspection of these bulbs as part of the general nursery inspection program and will accept certification on this basis from other States; that in Mississippi it is unlikely that any regulations will be placed; and that at the Central Plant Board meeting on February 27, while the matter was left in a somewhat uncertain status, it seemed clear that officers of the Central States would not place special requirements as to inspection and certification of these bulbs. An unconfirmed report is received that Texas has placed special regulations with reference to narcissus shipments. A record of the narcissus plantings inspected in the various states during the calendar year 1934, under the Federal quarantine relating to narcissus bulb pests, was issued by the Bureau of Entomology and Plant Quarantine as circular BEPQ-373, dated April 23, 1935.

Horizontal Movement of Larvae of the Japanese Beetle in Field Plots. Observations on larvae of the Japanese beetle in the field have indicated that at times they move horizontally in the soil for some distance. In preliminary studies under greenhouse conditions it was found that some larvae moved as far as 7 feet in 37 days. (Jour. Econ. Ent. 27:503–505).

An experiment to determine the extent of movement under field conditions was started in June 1933. Two plots, each 24 feet square, were enclosed with ⅛-inch mesh screen and given two fumigations with carbon disulphide to kill all larvae present. Grass seed was sown in one plot and the other was kept free of all vegetation. On September 22, 500 field-collected third-instar larvae were placed in a circular area 3 feet in diameter in the center of the fallow plot, and on September 25 the same number were placed in the sod plot. On October 23, one quarter of the fallow plot was dug up and the exact position of all larvae recovered was noted. On October 26, one quarter of the sod plot was examined. On May 7 and 8, 1934, two of the three remaining quarters of each plot were examined, while the fourth quarter of each plot was left until June 11 and 12 before it was dug up. The data on the distances covered and the recoveries in these plots are given below:

Time of examination	Grass sod			Bare ground		
	Larvae recovered	Average movement (Inches)	Greatest movement (Inches)	Larvae recovered	Average movement (Inches)	Greatest movement (Inches)
October 1933	104	7.2	18	107	12.0	41
May 1934	185	11.0	34	108	26.1	91
June 1934	53	17.4	34	22	51.0	114

In determining the movement of larvae, distances were measured from the edge of the circular starting area to the points where larvae were found. Many of the larvae, especially in the sod plot, did not move out of this area. The final position of a larva is not always a true measure of the distance traveled by that larva, for it has been found in other studies that larvae change the direction of their movement at frequent intervals. An examination of the data in the table shows that the horizontal movement of the larvae in bare ground was much greater than in grass sod. Recoveries were higher in the sod plot and larvae showed greater development in sod, for in the June examinations 16 individuals had transformed to the prepupal condition and 8 to pupae. None of the larvae in bare ground had made these changes.

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